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ABSTRACT

The two student notebooks in this set provide the basic course outline and assignments for the third year of a four year senior high school unified science program. This course is the less technical of the two third-year courses offered in the program. The first of the three major units in this course, Structure and Dynamics of the Biosphere, is composed of three sub-units: the nature and scope of ecological science, the ecosystem, and man in the biosphere. The second unit, Population Structure and Dynamics, contains four sub-units: structure and organization, the functioning of populations, population genetics, and human populations. The third unit, Problems of Coexistence, contains these sub-units: problems of coexistence with the physical environment, with other organisms, and within society. The final sub-unit of the course is Science and the Evolving Society. The notebook materials for each of the sub-units include: a list of required and recommended readings from various other books; questions for consideration in introducing a lesson; a brief background reading; a basic outline of the lectures with space provided within the outline for notes; laboratory activities and investigations; laboratory problem reports and other kinds of assignments (discussion questions, fill-ins, problems); and summary statements and review questions. Numerous diagrams and illustrations are included. (PR)

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Carl H. Pfeiffer
Wisconsin State Department of Education

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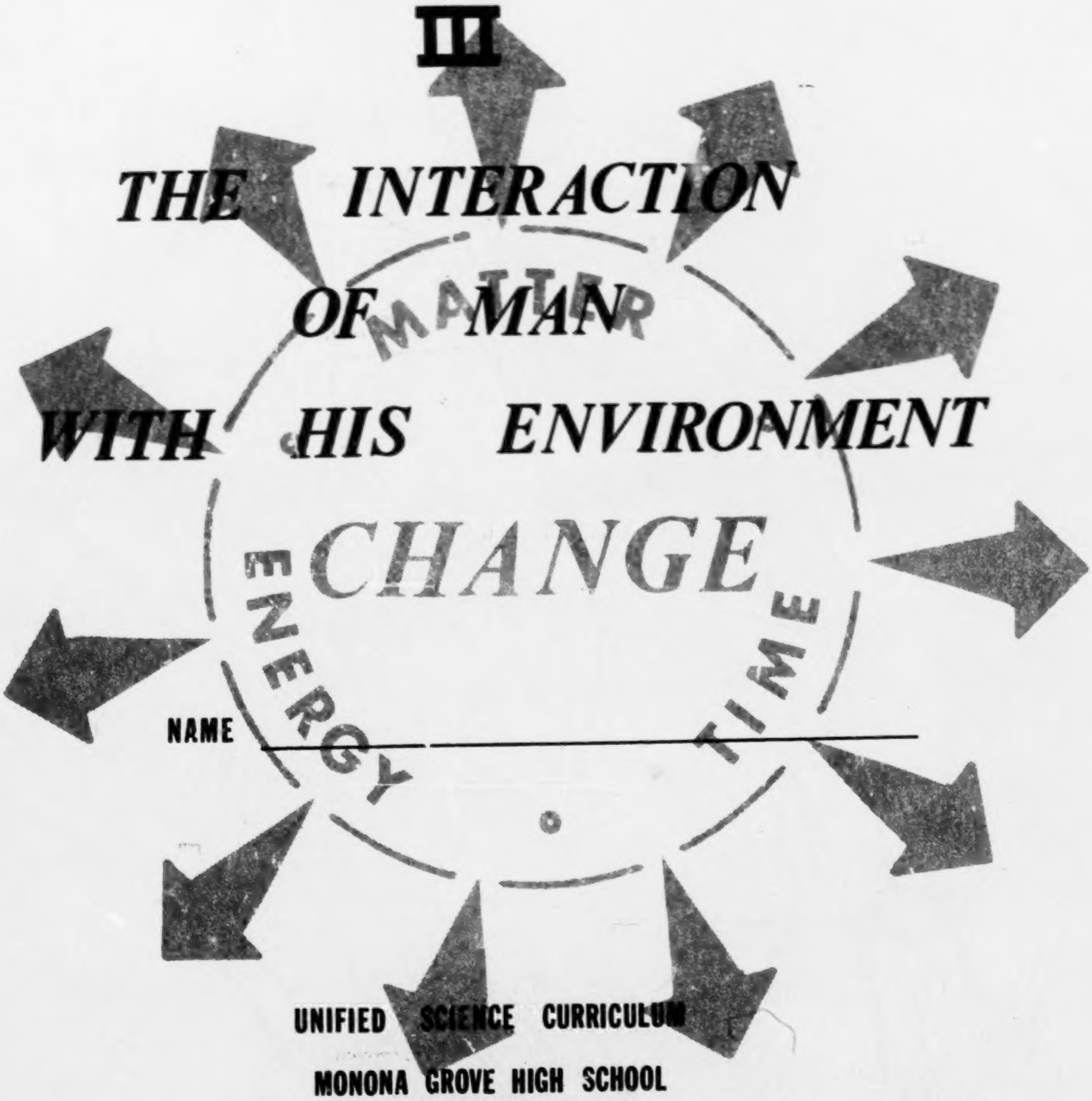
SCIENCE

III

THE INTERACTION OF MAN WITH HIS ENVIRONMENT



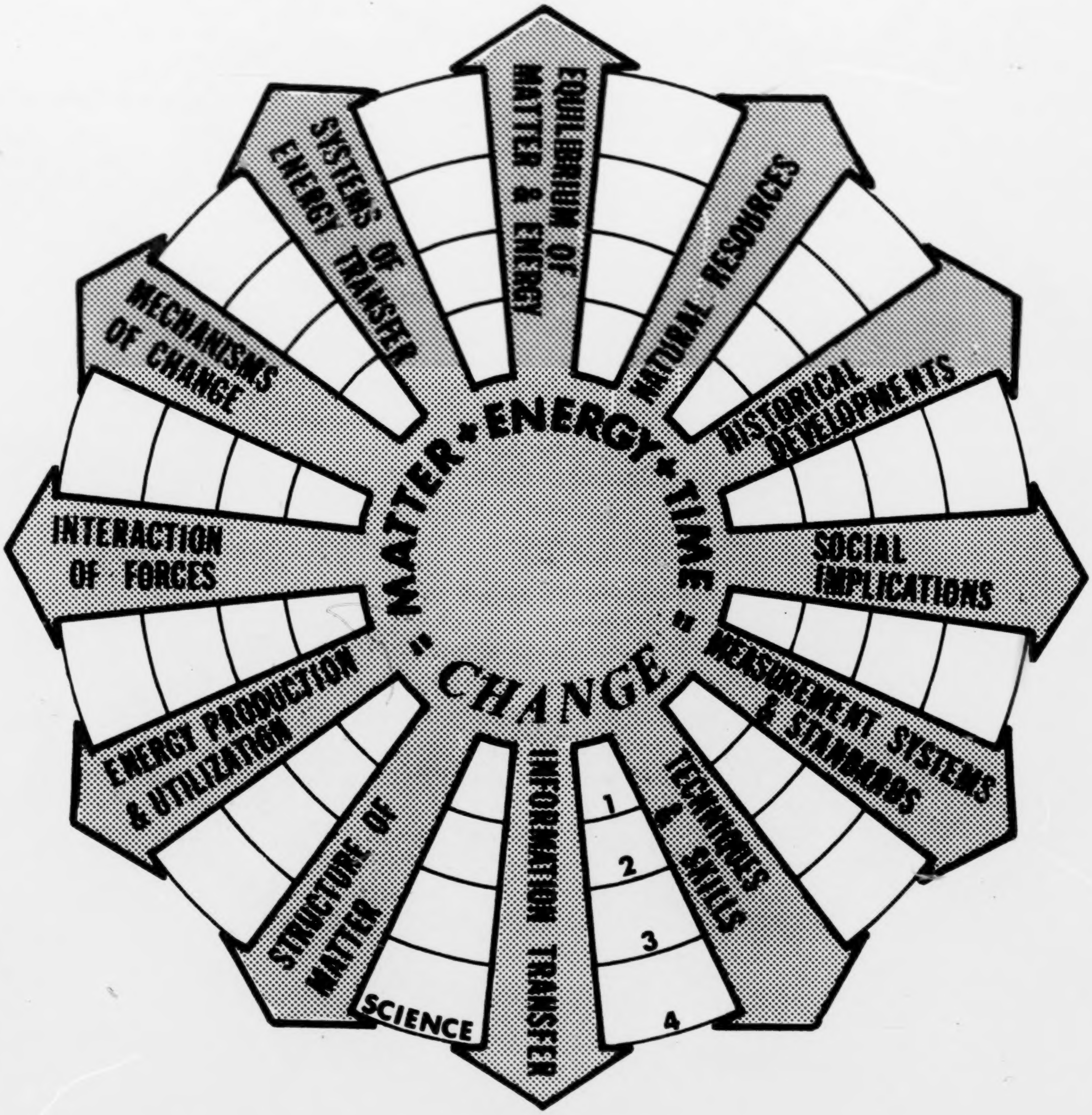
NAME ______________________________

UNIFIED SCIENCE CURRICULUM
MONONA GROVE HIGH SCHOOL
MONONA, WISCONSIN 53716
1968-69

SE 012 151
Part 1

UNIFYING THEMES

MONONA GROVE UNIFIED SCIENCE PROGRAM


EQUILIBRIUM OF MATTER & ENERGY
NATURAL RESOURCES
HISTORICAL DEVELOPMENTS
SOCIAL IMPLICATIONS
MEASUREMENT SYSTEMS & STANDARDS
TECHNIQUES & SKILLS
1
2
3
4
INFORMATION TRANSFER
SCIENCE
STRUCTURE OF MATTER
ENERGY PRODUCTION & UTILIZATION
INTERACTION OF FORCES
MECHANISMS OF CHANGE
SYSTEMS OF ENERGY TRANSFER
MATTER • ENERGY • TIME • CHANGE

INTRODUCTION

I. Class Procedures and Regulations

A. Grouping

1. Large Groups (50-55 Students) Rooms -- 67, 61
2. Laboratory Groups (24 Students) Rooms -- 61, 73, and 69
3. Small Groups (15-18 Students) Rooms -- 61, 73, 69, 67, 65 and other available rooms

When groups move from one room to another during a class session, the movement is expected to be accomplished quickly and quietly.

B. Personal Responsibility in the Classroom

1. When the bell signaling the beginning of a class session sounds, students are expected to come to order without further direction. Students not in their assigned seats at this time are considered to be tardy.
2. Students reporting to class late must present an "admit to class" pass.
3. The class will be dismissed by the teacher, not the bell, at the end of the class session.
4. Students detained by the teacher after the bell should obtain an admit to class pass before leaving the room.
5. Before leaving the classroom!
    a. Check your desk including the shelf and floor area to be sure that they are cleared of debris and in order.
    b. Place your chair under the desk.
6. The science department office located between rooms 61 and 65, is not to be used as a passage way by students.

C. Note Taking

1. The student notebook provides a basic outline of the course content.
2. Regular, careful, note taking in large group sessions is required in order to make the student notebook a useful reference for study.
3. An audio tape on effective note taking is available in the Resource Center.
4. Notebooks will be collected periodically to evaluate the quality of note taking.

D. Assignments

1. Assignment schedules will be given periodically. These schedules should be used to help budget time for homework and study for quiz sessions and hour examinations.

2. Types of homework assignments

   a. Reference reading:

      (1) Reading assignments will be made from selected references located in the Resource Center.

      (2) Generally the required reading assignments will also be available on audio tape.

      (3) "Check tests", one or two questions, will frequently follow a reading assignment.

   b. Problems, exercises and discussion questions:

      Duplicate copies of all problem assignments, exercises and discussion questions appear in the notebook. Carbon copies are handed in for evaluation.

   c. Laboratory reports - to be completed on special laboratory report forms.

3. Regulations pertaining to homework assignments

   a. On days when assignment is due at the beginning of the class session homework will be collected when the bell rings.

      (1) Problems, exercises or discussion questions missing after the collection of homework will be recorded as an F and be reflected in the Individual Performance Grade.

      (2) When excused absence is a factor the F may be converted to full credit provided that the assignment is completed within a specified period.

      (3) Laboratory reports missing at the time of collection will be graded F in Knowledge and Skills and affect the Individual Performance Grade.

      (4) If excused absence is not a factor, late laboratory reports may be submitted for a maximum of ½ credit in Knowledge and Skills.

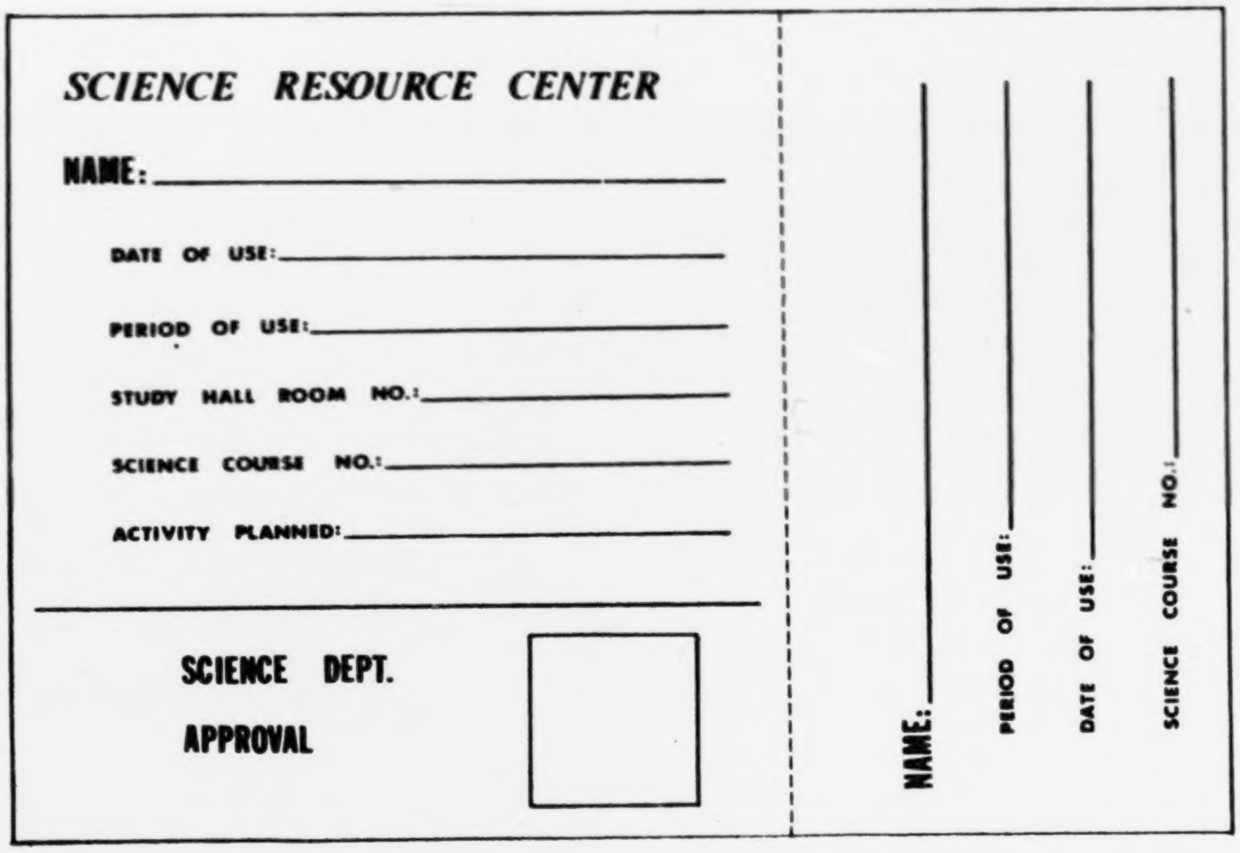
   b. Students absent from class are responsible for arrangements to complete assignments missed.

      (1) Assignments not handed in the day after returning to class will be graded as F, except in cases where requests for an extension of time have been approved.

      (2) Arrangements for making up a scheduled quiz or an hour examination must be completed the day the student returns to class. Any quiz or hour exam not made up will be averaged as F in the Knowledge and Skills Grade.

II. Science Resource Center

A. Use of the Resource Center Facilities



SCIENCE RESOURCE CENTER

NAME: ____________________

DATE OF USE: ____________________

PERIOD OF USE: ____________________

STUDY HALL ROOM NO.: ____________________

SCIENCE COURSE NO.: ____________________

ACTIVITY PLANNED: ____________________

SCIENCE DEPT. APPROVAL ☐

NAME: ____________________

PERIOD OF USE: ____________________

DATE OF USE: ____________________

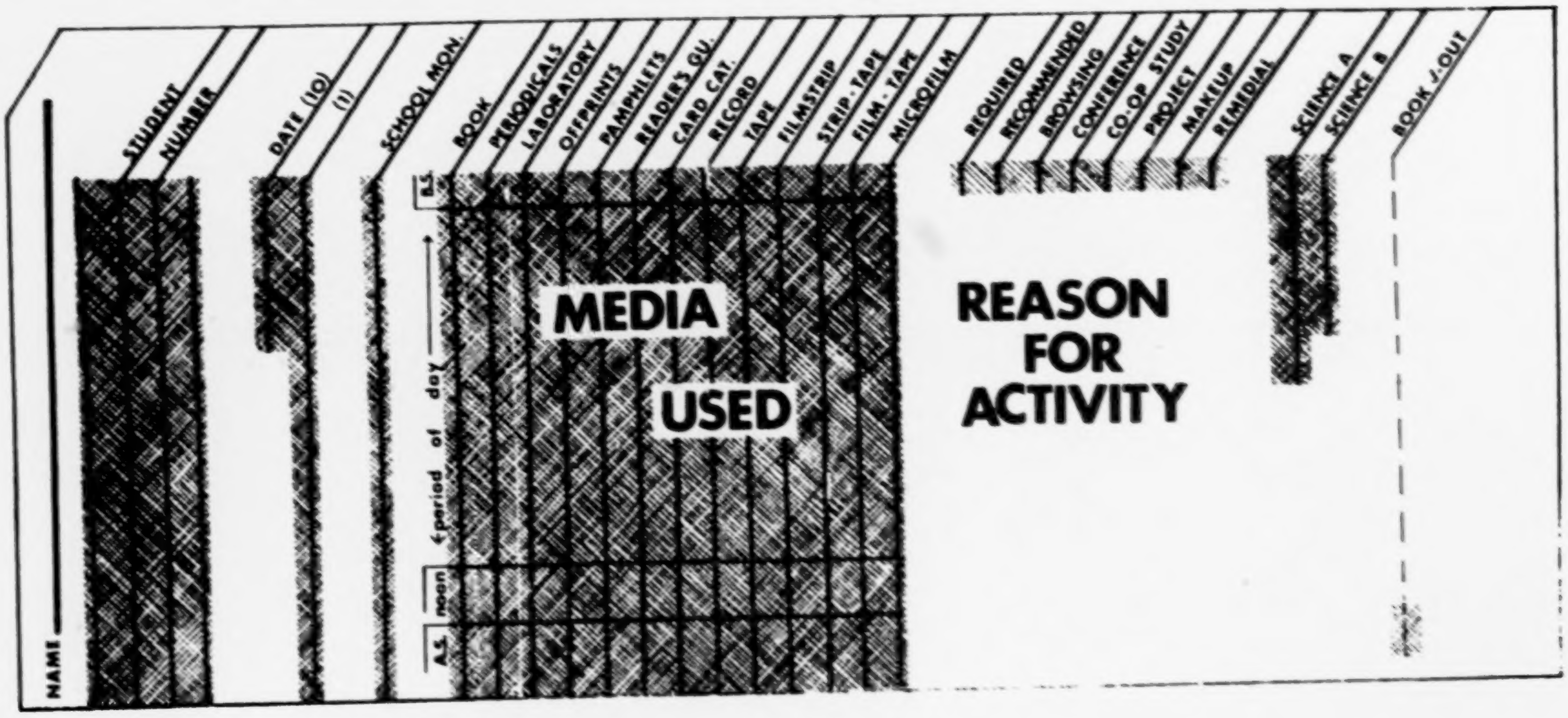
SCIENCE COURSE NO.: ____________________

1. The Resource Center may be used during any regularly scheduled study hall period by the "pass" system.
2. The Resource Center will be open from 12:15 to 12:45 every Tuesday, Wednesday, and Thursday noon.
3. Students wishing to use the Resource Center Facilities before or after school may do so by appointment.
4. Students must demonstrate the degree of self discipline necessary for effective independent or cooperative study in the Resource Center.

B. Circulation of Resource Center Reference Materials

1. No materials will be checked out during the school day.
2. Books, magazines, offprints, and special materials may be checked out on an "overnight" basis only. Check out period is from 3:45 to 4:00 p.m. daily.
3. All materials must be returned by 8:00 a.m. the next day.
4. Failure to comply with any of the above procedures will be reflected in the Citizenship Grade.

C. Use of the Porta-Punch Card


STUDENT
NUMBER
DATE (10)
(1)
SCHOOL MON.
BOOK
PERIODICALS
LABORATORY
OFFPRINTS
PAMPHLETS
READERS GU.
CARD CAT.
RECORD
TAPE
FILMSTRIP
STRIP-TAPE
FILM-TAPE
MICROFILM
REQUIRED
RECOMMENDED
BROWSING
CONFERENCE
CO-OP STUDY
PROJECT
MAKEUP
REMEDIAL
SCIENCE A
SCIENCE B
BOOK √-OUT
NAME
B.S.
period of day
noon
A.S.
MEDIA
USED
REASON
FOR
ACTIVITY

1. Print your name on the card.
2. Punch out the correct information on the shaded (red) area.

D. Guide to Student Use of the Science Resource Center

1. The Science Resource Center is designed and equipped to provide an opportunity for students to do independent or cooperative study in the area of science.
2. Students who come to the Resource Center must have a specific purpose which requires the use of the facilities in the Center!
3. Students who use the Resource Center Facilities must record the nature of their activity in the Center by use of the Porta-Punch Card.
4. All cooperative study between two students must be done at the conference tables. Students sitting at the study carrels are expected to work individually without any conversation with other students.
5. All students are encouraged to take advantage of the opportunities that the Resource Center provides for individual help with any problems or difficulties experienced in their science course.
6. The use of the Resource Center Facilities requires self discipline on the part of the student in order to develop effective individual study skills. Students who are unable to exercise the self discipline required to maintain an atmosphere conducive to independent study will not be permitted to use the Resource Center Facilities until such time that they can demonstrate this ability.
7. Maintenance Responsibilities
    a. Turn volume off when headsets are not in use.
    b. Leave all reference books on the carrel shelf in good order. All cataloged books and periodicals are to be returned to the proper space in the drawers or shelves.
    c. Keep desk storage area free of debris and desk surfaces clean.

III. Grades and grading

A. Basis for the evaluation of Individual Performance and School Citizenship:

*See accompanying sheets or student handbook for points considered in grading these categories. Individual Performance and School Citizenship will be evaluated three times each quarter.

B. Basis for the evaluation of student progress in the area of Knowledge and Skills:

1. The grade point system

4.0 3.9 3.8	4.3 A+
3.7 3.6 3.5	4.0 A
3.4 3.3 3.2	3.7 A-
3.1 3.0	3.3 B+
2.9 2.8 2.7	3.0 B
2.6 2.5	2.7 B-
2.4 2.3 2.2	2.3 C+
2.1 2.0 1.9	2.0 C
1.8 1.7 1.6	1.7 C-
1.5 1.4	1.3 D+
1.3 1.2 1.1	1.0 D
1.0 .9	.7 D-
.8 .7 .6 .5	.3 F+
.4 .3 .1 .0	.0 F

2. Determination of grade point

Daily Work - ½ of Knowledge and Skills Grade

Quizzes a. short 5 minute unannounced test covering material presented in large group sessions or homework assignments

b. 15-30 minute announced test

Written laboratory problem and investigation reports

Hour Examinations - ½ of Knowledge and Skills Grade

Daily work and hour examinations not completed will be averaged as zero.

C. Final Total Growth Grade

1. Each of the four, quarterly, total growth grades plus the Final Evaluation are averaged equally to give the final Total Growth Grade in the course.

2. Final Evaluation

a. The final written examination in the course will count as one-half of the Final Evaluation.

b. A final appraisal of Individual Performance and School Citizenship will determine the remaining half of the Final Evaluation Grade.

FACTORS DEFINING INDIVIDUAL PERFORMANCE

Works up to ability

1. Does work which compares favorably with ability as measured by test scores.
2. Does daily work which compares favorably with best work done in a grading period.
3. Tries to make the best use of his particular talents and opportunities.
4. Carefully completes each day's assignment.
5. Reworks and corrects errors in assignments after class checking.
6. Goes beyond regular assignments to learn more about the subject.
7. Spends time reviewing.
8. Shows improvement rather than staying at one point.

Has a positive attitude

1. Has a sincere desire and interest in learning.
2. Is willing to try - is willing to be exposed to new information and ideas.
3. Has respect for the opinions of others.
4. Accepts correction well and constantly tries to improve.
5. Takes pride in his work.
6. Responds as well to group instruction as to individual instruction.
7. Does not argue over trivial points.
8. Does not show negative feelings in class - straightens things out alone with teacher.
9. Is willing to accept special jobs.

Shows self-direction

1. Demonstrates ability to carry on independent or cooperative study using Resource Center materials.
2. Works for understanding rather than a grade.
3. Is self-starting and self-sustaining.
4. Does his own work - has confidence in it.
5. Tries assignments himself before seeking help.
6. Knows when and how to seek help.
7. Initiates makeup assignments and does them promptly.
8. Is resourceful- uses imagination.
9. Settles down to work immediately.
10. Shows initiative.

Plans work wisely

1. Completes assignments and turns them in on time.
2. Is prepared for class - brings all necessary materials.
3. Makes good use of study time.
4. Follows directions.
5. Anticipates needs in work projects.
6. Organizes time so there is no last minute rush job.
7. Moves quickly and quietly when given an assignment.

FACTORS DEFINING SCHOOL CITIZENSHIP

Is courteous and considerate of others

1. Is courteous to other students, to teachers or any person with whom he comes in contact, for example the custodial staff.
2. Is quiet and attentive in class discussion.
3. Listens carefully to student questions, answers and comments as well as to those of the teacher.
4. Uses only constructive criticism - avoids ridicule.
5. Is tolerant of errors made by others.
6. Receives recognition before speaking.
7. Is ready to begin work when the bell rings.
8. Accepts the "spirit" as well as the letter of school regulations.
9. Shows halllway conduct which is orderly and in good taste.
10. Shows good assembly conduct.
11. Is quiet and attentive during P.A. announcements.
12. Is quiet in hallways when school is in session.
13. Carries out classroom activity in a quiet and businesslike manner.

Is responsible

1. Demonstrates self discipline necessary for effective use of Resource Center Facilities.
2. Keeps appointments.
3. Carries out assigned tasks.
4. Can be left unsupervised for a period of time.
5. Gets to class on time.
6. Meets obligations, fees, etc.
7. Returns borrowed items.
8. Has a good attendance record.
9. Keeps name off library list.
10. Presents excuse for absence.
11. Returns report card on time.

Contributes his share

1. Works to develop and uphold the good reputation of the school.
2. Participates in class discussion in a constructive manner - asks questions as well as volunteering information - shares ideas.
3. Participates in at least one school activity as a cooperative, contributing member.
4. Accepts jobs such as taking part in panels, putting up bulletin boards, helping direct class activities, getting information.
5. Brings examples, clippings, supplementary materials to class.
6. Contributes to success of class in a physical way - straightens chairs, pulls blinds, etc.

Is a good leader or follower

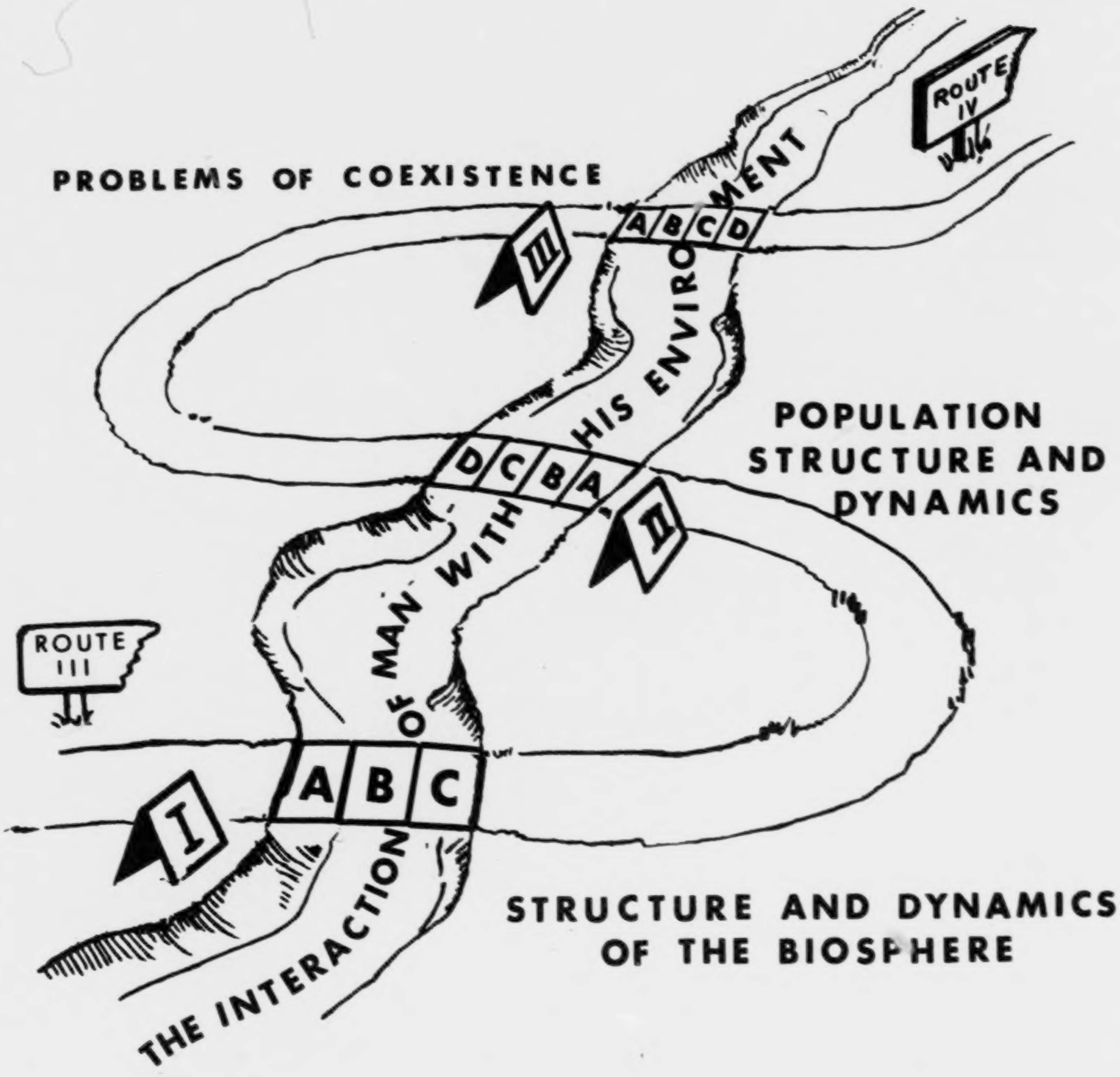
1. Cooperates willingly with the majority even though his point of view is with the minority.
2. Works constructively to change practices he is not in agreement with.
3. Works willingly with any group, not just his particular friends.
4. Helps class move along positively.
5. Leads in class discussion.
6. Responds to suggestions.

7. Gets others to participate.
8. Helps other students learn without simply giving them answers.
9. Is compatible with the group or class.
10. Avoids trying to be the center of attention.

Takes care of school and personal property

1. Handles and uses school equipment and materials with care.
2. Cooperates in keeping school building and grounds clean, free from litter and in excellent condition.
3. Is concerned about clean-up at the end of a class period.
4. Erases pencil marks and picks up paper when others have been careless.
5. Respects property of others.
6. Returns materials to correct places.
7. Avoids marking desks, books, etc.
8. Covers text books.
9. Disposes of gum, paper, etc., properly.
10. Keeps locker clean.

SCIENCE IIIB


PROBLEMS OF COEXISTENCE
POPULATION STRUCTURE AND DYNAMICS
STRUCTURE AND DYNAMICS OF THE BIOSPHERE
THE INTERACTION OF MAN WITH HIS ENVIROMENT
ROUTE IV
ROUTE III
I
II
III
A B C
D C B A
A B C D

THE INTERACTION OF MAN WITH HIS ENVIRONMENT

I. STRUCTURE AND DYNAMICS OF THE BIOSPHERE

- A. The Nature and Scope of Ecological Science
- B. The Ecosystem
- C. Man in the Biosphere

II. POPULATION STRUCTURE AND DYNAMICS

- A. Structure and Organization
- B. The Functioning of Populations
- C. Population Genetics
- D. Human Populations

III. PROBLEMS OF COEXISTENCE

- A. Problems of Coexistence with the Physical Environment
- B. Problems of Coexistence with Other Organisms
- C. Problems of Coexistence Within Society
- D. Science and the Evolving Society

We Are on A Collision Course With Nature

taken from an article by John Newhouse
which appeared in the WISCONSIN STATE JOURNAL
March 30, 1969.

By about 6000 B.C., man had learned how to irrigate crops, and the first civilization developed: the Sumerians of Mesopotamia.

There was a baby boom, with all that new food.

People moved to cities, like Ninevah and Babylon.

There was a need for lumber. They cut the upland forests of the Tigris and the Euphrates rivers. Dirt washed down into the irrigation ditches. The Sumerians shovelled manfully, until dirt on the ditch edges was 50 feet high.

Fish died in the muddy waters. Crops failed. And, finally, the Sumerians had to give up their battle with nature. Their civilization declined and was forgotten.

"This drama has occurred time and time since," says David Archbald, managing director of the University of Wisconsin Arboretum.

"Man has always exploited nature to satisfy his immediate needs, dumped his wastes and, if need be, moved on.

"But, now there are no more places for him to go."

Man, he says, is on a collision course with nature.

"If man continues blindly pursuing his present course, which is likely, the collision will be painful: mass famine in an environment degraded to the point which will challenge his survival."

The collision began, he says, when man first "walked out of the woods" some 10,000 years ago, moving into the Stone Age. He had been living in harmony with nature, up to then.

"Then he turned to agriculture," says Archbald. "The rats he once ate became competitors for his grain. He brought unnatural concentrations of plants together in what he called "fields". The insects were happy. Their numbers burgeoned. No longer did they have to forage afar for food. Man had brought it into one place for them."

Communities grew. Trading began, and there were roads. The Sumerians came, and went. And nature struck back, sometimes slow and unnoticed, sometimes with dramatic effect: the bubonic plague which killed one-fourth of the world's population in the 1300s; the famine which killed 9 million Chinese in

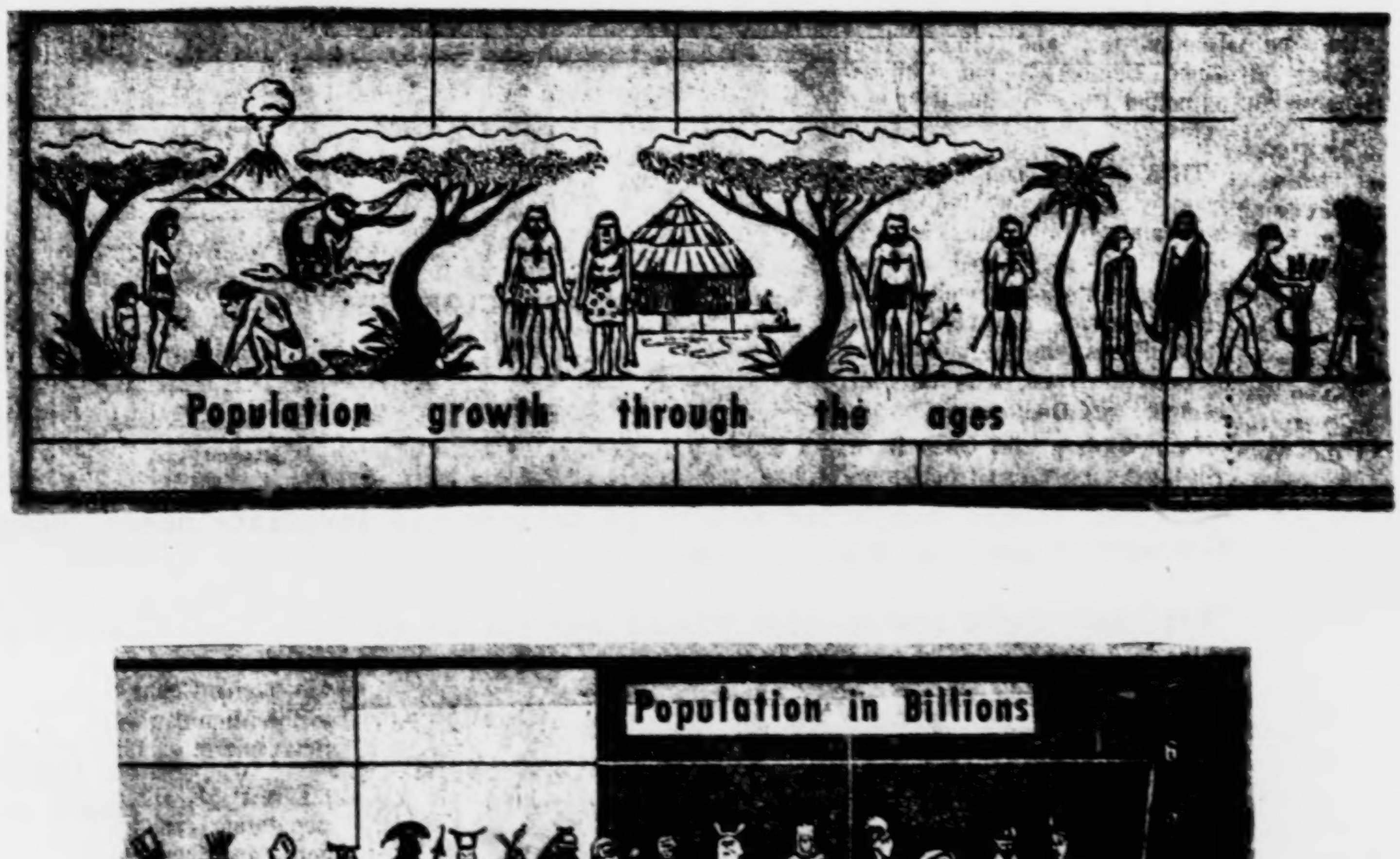
2 the late 1870s, and the flu epidemic which followed World War I and killed 25 million.

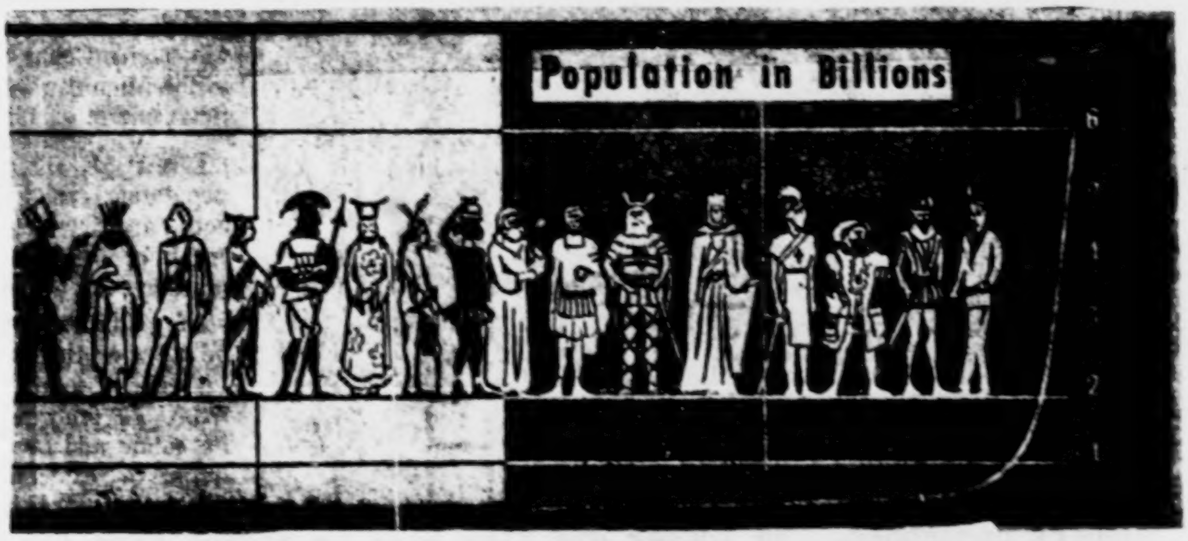
The baby boom of the Sumerians was a tiny thing, yet by the 1790s Thomas Malthus was predicting:

"Life on this planet is so prolific that, if allowed free to develop itself, it would fill millions of worlds in the course of a few thousand years."

"He had little to work with, yet he correctly predicted that the population, when unchecked, would double itself every 25 years, and hence increase geometrically."

In the next 30 years, Archbald says, the population of the under-developed nations will increase 100 per cent, and that of the developed nations by 40 per cent.


Population growth through the ages



The population curve, almost flat from 2000 B.C. to 1500 A.D., is zooming almost straight up to a predicted 6 billion in 2000 A.D. - double the 3 billion of this year.

Back in the days when the Pilgrims stepped ashore at Plymouth Rock, North America was a multi-billion-acre wilderness. But look what man has done to it.

The 2 million acres of Wisconsin prairie have shrunk to less than 1 per cent. The California redwoods have dropped to 3 per cent of the original 2 million acres. The 5 billion passenger pigeons are gone, and the 50 million bison are down to 1/100 of 1 per cent. And we are presently converting more than 1 million acres of land each year to highways and building sites. As if the physical attach on the land were not enough, consider the chemical. What has come to be known as the Effluence of Affluence is staggering.

"Air pollution is now estimated to cost each person $65 per year. This is only the beginning. Yet Congress in 1969 appropriated only about 45 cents per person to combat this loss."

Aeons ago, the high concentrations of carbon dioxide in the air were turned to fossil fuels - oil and coal - and locked in the ground. A balance of nature was struck, and man developed. Now man is wrenching the fossil fuels out of the earth again and, in burning them, is pouring carbon dioxide back into the atmosphere. Climatologists disagree on the effect. It's been suggested that there'll be a "greenhouse effect", with heat trapped in the atmosphere. Warm weather may be fine, but:

Some feel that gradual warming could melt the Antarctic ice cap. This could raise sea levels by 400 feet. If this takes 1,000 years - and it could occur sooner - there would still be a 4-foot rise every 10 years and in two or three decades many of the world's largest seaports would be inundated.

Between 1885 and 1940, the mean temperature rose by 1 degree. But, in the 20 years following, there was a 2/10 of a degree cooling, casting doubts on the theory. The new theory is that increasing dust in the atmosphere has a cooling effect.

"Unfortunately, it's not as simple as one counteracting the other," says Archbald. "Atmospheric dust and carbon dioxide have quite different effects on such factors as light quality and intensity, the photosynthesis by which plants use light to make food, wind direction and velocity, and water acidity."

Meanwhile....every year, cars, buses, and trucks put 85 million tons of pollutants into the air, a grand total of 130 million tons of air pollution. And water, without which man dies in a few days, is also in danger. Lake Erie is an example of what is happening. Lake Erie was born some 10,000 years ago, about the time man began walking out of the woods. It was a balanced ecological system - or ecosystem - when the European arrived.

"And how he must have admired its abundant yields of game fish, its flights of canvasbacks, geese, and swans, its aerial dance of the mayflies on beaches like Lorraine, its intemperate storms and its innocent tranquility."

Now it's a sewer.

The cicso, sauger, and whitefish, numbering in the millions before World War II, are now down to a "trace." Carp, sheepshead, and channel catfish have doubled. The change, says Archbald, is brought about by the industrial pollutants, including acids, oils, cyanides, phenols, human sewage, farm insecticides and fertilizers, and the weed killers.

4 "Until recently, it was thought that Lake Erie served as a waterway to carry wastes to the sea," says Archbald. "Not so! The lake is a waste trap!"

While mankind has been complacently emptying wastes into the big lake, the algae have been increasing, just as grass grows better when fertilized. The algae have died, and been attacked by bacteria. This takes dissolved oxygen which, locked in new compounds, has sunk to the bottom of the lake. Without oxygen, the mayfly nymphs that hatch on the bottom of the lake, and which constitute a favorite fish food, have died. So the numbers of game fish have fallen off.

The lake bottom was covered with a "skin" of ferric oxide, insoluble in water, which locked the nutrients caused by algal death and decay on the bottom. But, with the oxygen gone, the ferric oxide turned to furrous oxide, which was water soluble. This unlocked the nutrients. There were large blooms of algae, with the new food supply.

"And the whole deadly cycle escalates to a higher and more destructive level."

Recently, to make things worse, the blue-green algae which can take nitrogen from the air and, decaying, release it to the lake have been on the increase. We are rapidly converting a crisp, clean blue lake into a listless murky green aquatic desert, our American 'Dead Sea'.

And what goes on, dramatically, in Lake Erie, is occurring everywhere. In 1900, for instance, the sewage systems of the United States put some 10 million pounds of phosphates into the nation's waters. By 1960 due largely to synthetic detergents, it was 250 million pounds.

Several years ago, the National Research Council warned that by the mid-1980s, the increase in sewage would demand ALL of the dissolved oxygen in our lakes and rivers. "That would be the end of aquatic life," says Archbald.

And this doesn't take into account the effect of the warming of the waters caused by atomic power plants, which stimulate algal growth. In Lake Michigan, the big change comes from use of DDT.

"Just as man did not understand what was happening in Lake Erie until recently, he did not realize that DDT would move so rapidly through the bio-geographical pathways."

"Nor did he realize until recently that DDT would be so readily concentrated in the fatty tissues of predatory animals of the food chain."

In Clear Lake, Calif., DDT entered at the rate of 2-100 of 1 part per million. It showed up in plankton at the rate of 10 parts per million. Fish ate the plankton. Birds ate the fish that ate the fish that ate the plankton. In the birds, the concentration was 100,000 parts per-million.

"And what of man, who stands at the top of the food chain?"

We are now exposing ourselves, and our environment, to about 50,000 different chemicals, adding 400 to 500 new ones a year. And their effect? "The simple truth is that we just do not know. We are selling our virtue to buy wealth. We are trying to rule, without knowing the rules. Yet: the more that man manages, the more he has to mange. If he extirpates a natural predator, then he has to step in and assume that predator's role or risk being overrun by the now-uncontrolled prey."

"Can he poison the target pest plants and animals, and yet not poison the insects which pollinate the plants whose food he needs, not poison the bacteria which cause necessary decay, nor poison the earthworms which make the earth fertile, or the ocean diatoms which produce 70 per cent of the oxygen we breathe?"

The world's ecological systems have been coping with smaller assaults of pollutants and adapting, over the years but now, the assualt is so heavy that adapting may not be possible. Well over half of the plant species have been lost.

"Usually man becomes aware of an ecosystem dislocation only when his own ox is gored, when 'his' multimillion pound yield of Lake Erie cisco, once the dominant species, is depleted or gone."

Nor do we know the relationship of one species to another, and the extent to which they are 'hooked in' and necessary to our survival, a fact that caused the late Aldo Leopold to say: "How do we know but, when we pick a pasque flower, that we change the course of a star?"

As we move ahead, Archbold says, the problems worsen. If we remove the equivalent of today's pollution from the world of 15 years from now, we will not have bettered ourselves, for the pollutants are doubling. Cleaning up a lake, he says, may be all but impossible, for bringing back the organism is difficult enough, but bringing it back in the delicate balance it was before is something else. We have consoled ourselves in thinking we will farm the sea.

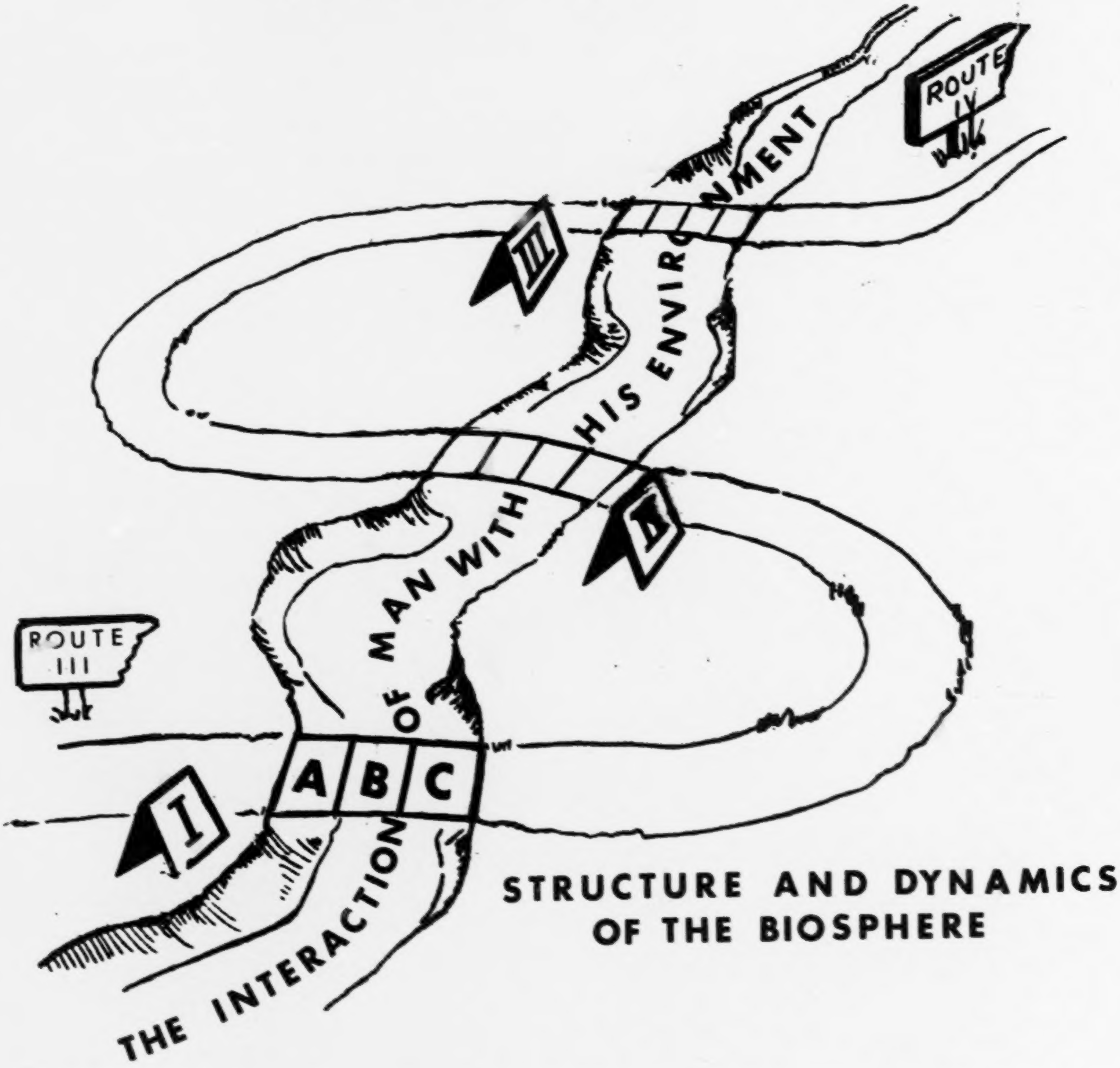
But, in 1955, the world catch of marine food was just enough for 25 million people. In a decade, it had doubled, to enough to feed 46 millions. But, in that decade, the world population had increased 500 million!

The polluting of coastal areas of the sea, where pollution is easiest and so many marine animals reproduce and live a part of their life, places the sea itself in jeopardy.

The only answer to the problem Archbald sees is a greatly aroused public, putting pressures on the government, correcting as much of the damage as yet can be corrected before it is too late. And, along with this, controlling the population.

"Saying that a population explosion is a problem of the underdeveloped nations is, to quote an eminent authority, like saying to a fellow passenger, 'Your end of the boat is sinking.'

SCIENCE IIIB


ROUTE IV
ROUTE III
III
II
I
A
B
C
THE INTERACTION OF MAN WITH HIS ENVIRONMENT
STRUCTURE AND DYNAMICS OF THE BIOSPHERE

A. THE NATURE AND SCOPE OF ECOLOGICAL SCIENCE

B. THE ECOSYSTEM

C. MAN IN THE BIOSPHERE

THE NATURE AND SCOPE OF ECOLOGICAL SCIENCE

The Scope of Ecology

Levels of Organization Within the Biosphere

The Ecosphere

Major Biomes and Their Subdivisions

The Nature and Scope of Ecological Science

THE SCOPE OF ECOLOGY

Required Reading: Ecology, Eugene Odum, Chapter One: "The Scope of Ecoloty", pages 1-16

QUESTIONS FOR CONSIDERATION:

1. For what reasons is it imperative that every person become informed and take some concern about environmental processes and conditions goin on in nature?

2. Basically why has the plea for more trained persons in the field of ecological science become so urgent?

3. Explain what the author refers to when he uses the terms:

   a. energy flow -

   b. biogeochemical cycles -

4. What two specific problems were referrred to by the author that had to do with man's interference with energy flow and biogeochemical cycles? Cite two additional problems that you are aware of from reading the newspapers and magazine articles.

5. Why must trial - and - error procedures be avoided in attempting to correct or compensate for environmental problems?

6. In your daily newspaper, find and bring to class as many articles as you can find that describe situations where man is attempting to alter his environment with the hope of improving it. In each case, consider what the criterion for improvement is, what short-sightedness may be involved, whether long-range or short-range advantages are sought for, and finally, what you believe the outcome will be.

7. Also bring in articles descrbing cases where man is thoughtlessly altering his environment in a destructive way without consideration for the long-range disadvantages to himself and to others. What measures would you suggest to be taken to correct for or eliminate such a problem?

8. How does the author define ecology?

9. Propose a definition of nature that would be acceptable to the author.

10. List in order (from smallest to largest) the levels of organization within the biological "spectrum" and define the meaning of each level.

7

11. What levels are of chief concern to the ecologist? Why?

12. As the author points out, some aspects of analysis become more complex as we proceed from the study of cells to the study of ecosystems. However, this problem is compensated for by the fact that other aspects become less complex and variable as we go from small to large units. What is the chief reason for this? Give an example in addition to the one given by the author.

13. What is meant by the term, homeostasis? Give several examples of homeostasis at the ecosystems level.

14. What is meant by homeostasis at the population level?

15. The author refers to the biological "spectrum" as a "continuous scientific front". What does he mean by this? How is man's understanding of any one part dependent upon the advance of the whole front?

16. What chief criticism does the author have in regard to the areas that man has chosen to advance in order to gain knowledge about himself as an organism along with other organisms?

17. Why is the study of the function of nature more meaningful and more important than the study of its structure alone?

18. Could the function of nature be studied by itself without concern for its structure? Why?

RESEARCHERS MAY END POLLUTION - AND THE BAIT INDUSTRY

Article from the CAPITAL TIMES, Madison,
by Irvin Kreisman

WILL SALAD-SNAPPING FISH EAT UP LAKE WEED PROBLEMS?

Could it be that a fish that prefers a salad to a steak is the answer to the weed problems in Madison's lakes?

Maybe the advocates of chemical herbicides and the propenents of more weedcutters are both wrong.

Perhaps the solution to controlling excessive plant growth in water is, of all things, a plant-eating fish. Anyway the Illinois Natural History Survey, with headquarters in Urbana, is trying to find out.

A number of years ago the survey obtained six of these fish - called tilapias, or mouth breeders, because they carry eggs and young in their mouths - from fishery researchers in Alagama.

The tilapias are said to be fast growing and produce rapidly. Originally they were imported into the United States from Africa.

But there's not much danger that the fish will take over a lake, munch up all its weeds, and cause a surplus of stunted tilapias.

The reason? The fish is unable to survive in water temperature below 50 degrees (Fahrenheit). Thus there would be no buildup of large stunted populations.

Since the fish grow and reproduce rapidly, it has been suggested that they could be raised indoors easily and economically. Comes spring they could be sold each year to aliminate algae and all types of aquatic vegetation during the entire growing season.

The Illinois Natural History Survey has been experimenting with the finny creatures from Africa since 1962. Dr. George W. Bennett, head of the group's aquatic biology section, and Dr. William F. Childers, survery aquatic biologist, are attempting to find out if the vegetarian fish could eliminate excessive algae and rooted aquatic weeds in a small pond near Monticello, Ill.

The annual summer experiments have proved to be encouraging. In the most recent tests the fish got rid of overgrown weeds and algae in six weeks and kept the pond clean the remainder of the summer.

Now studies are being conducted to determine how many fish are necessary to control the vegetation.

Thus far, Drs. Bennett and Childers have discovered that it takes somewhere between 100 and 200 five-inch-long tilapias per acre to control the water weeds in the 2½-acre pond.

I CAN'T
RESIST
IT!
HINRICHS

In addition to their appetites, tilapias have other uses. For example, they are excellent bass food. This was realized after the 1963 experiments when tilapias and a large number of bass were stocked in the pond in April and May.

By fall, when the pond was drained, the bass had eaten nearly all the tilapias and the weeds had taken over.

Since 1963, different numbers and sizes of tilapias have been stocked during the latter part of May. Then in July, largemouth bass, approximately one inch in length, have been placed in the pond.

With several weeks head start over the bass, the tilapias have been able to build up a sizable population, keep the pond clean and still produce enough young to satisfy the bass' appetite.

It is reported that the survey biologists realize that these African imports cannot be practically or widely used until they can be stocked in ponds and lakes already containing other kinds of fish.

Therefore, plans have been made to place six-inch long tilapias in six ponds containing bass and bluegills. According to Dr. Childers, tilapias a half-foot in length are relatively safe from attack by other fish.

The tilapia is said to be a tasty fish, capable of giving anglers a sporting fight.

Can't you see it now? - Mendota and Monona in a few years covered with fishermen baiting up their hooks with choice lettuce adorned with various assortments of mayonnaise, Thousand Island or Roquefort, all to catch a mess of tilapias.

Well, there have been bigger fish stories.

LEVELS OF ORGANIZATION WITHIN THE BIOSPHERE

I. Frames of Reference Within the Biosphere

A. The Biological "Spectrum"

1. Levels of Organization Within the Universe of Living Matter	2. Scientific Disciplines Devoted to Focusing Attention Specifically to a Given Level

B. Levels of Chief Concern to the Environmental Scientist (bracket the ones above)

1. Individuals

a. Definition

b. Classification of Individuals

(1) Dependent Upon -

(2) Convenience of Classification -

c. the Meaning of Individuality

2. Populations
    a. Definition

    b. Space-Dependent Property of a Population

    c. Density

    d. Change
        (1) Measurement of Change

        (2) Causes of Change

3. Communities
    a. Definition
        (1) Restricted

        (2) Broadened

    b. Change Dependent On
        (1) Biotic Factors

        (2) Abiotic Factors

c. Stages of Change

    (1) During Succession

    (2) At Climax

4. Ecosystems

    a. Definition

    b. Requirements

5. Biosphere

    a. Definition

    b. Major Areas

    c. Overlapping of Areas

THE ECOSPHERE

Required Reading: The Ecosphere, L.C. Cole, Scientific American, April 1958, Offprint #144

I. The Concept of Ecosphere

   A. Derivation of the Term

      1. Lamarck's Idea of Biosphere

      2. Vernadsky's Idea of Ecosystem

      3. Cole's Employment of Their Terms

   B. Interdependence of Biotic and Abiotic Components

      1. Plant and Animal Life and Energy Flow

      2. Plant and Animal Life and Biogeochemical Cycles

         a. Water Cycle (Hydrogen and Oxygen)

         b. Carbon Cycle

         c. Nitrogen Cycle

d. Phosphorus Cycle

C. Ecosphere Conceived as the Largest Possible Ecosystem

II. Energy for the Ecosphere

A. Sources

1. External

2. Internal

B. Efficiency of Ecosphere in Capturing Energy

1. Reflected Portion

2. Absorbed Portion

   a. Thermal Absorption

   b. Photosynthetic Absorption

C. Utilization of Energy Within the Ecosphere

1. Efficiency of Energy Flow Through the Biosphere

   a. Losses at Each Level

   b. Gains in Terms of Efficiency of Biomass Production

2. Length of Food Chains in Relation to Efficiency

   a. Natural Limit to the Length of Food Chains

   b. Necessity of Shortening Food Chains to Support Large Populations

3. Other Pathways for Energy Flow
    a. Parasites

    b. Decomposers

    c. Transformers

III. Total Productivity of the Ecosphere
    A. Limits Set on the Amount of Life that the Earth Can Support

    B. Importance of the Water Cycle to Productivity
        1. Physiological and Biochemical Requirements
            a. Requirements of Protoplasm

            b. Requirements for Production of Dry Organic Matter

            c. Other

2. Water as a Transport Medium

3. Water as an Agent of Erosion

C. Importance of Dissolved Forms of Matter to Productivity

1. Mineral Requirements of Plants and Animals

2. The Big Three

   a. Nitrogen

   b. Carbon

   c. Phosphorus

D. Phosphorus: The Critical Limiting Resource

1. Importance of Phosphorus to Life

2. Magnitude of Losses

3. Problem of Recovery

E. Other Essential Elements and Their Relationship to Productivity

1. Calcium

2. Potassium

3. Magnesium

4. Iron

IV. Summary and Evaluation

A. Chances of Error in Cole's Estimates

1. Liklihood of Overestimation and Underestimation

2. Problem of Error Due to Irregular Distribution of Resources in Time and Space

B. Justification for Man's Concern

1. His Carelessness

2. Increasing Need to be Concerned

C. Estimates of Total Productivity

1. Tons of Protoplasm per year

2. Human Population

   a. Present Size

   b. Kilocalories Consumes per Person Per Year

   c. Kilocalories of Plant Matter Available Per Year

   d. Man's Requirement

      (1) As a Herbivore

      (2) As a Carnivore

3. Human Diets in the Future

MAJOR BIOMES AND THEIR SUBDIVISIONS

Recommended Reading: BSCS Green Version, Chapter 8, pages 250-304

BIOME:

1. a complex of communities characterized by a distinct type of climax community; i.e., by a uniform life form of the climatic climax; i.e., is coincidentic climax
2. the largest land "community" recognizable - these are the great "plant regions" of the world; however, animals are also characteristic of biomes
3. contain edaphic, seral, sub- and dis-climax communities; also each consists of several major climax communities - but these later all have the same life form - and many minor communities
4. result largely of equilibria of living inhabitants with all aspects of climate of region. - thus the divisions are largely latitudinal; exception in North and South America

MAJOR BIOMES:

tundra, taiga or northern coniferous forest, temperate deciduous and rain forest, grassland, desert, chaparral, tropical forest (with subdivisions of rain, deciduous, etc)

MOUNTAIN ZONATION:

reflects point four above - distribution of biomes altitudinally rather than latitudinally; altitudinal distribution differs latitudinally, however

TUNDRA:

low temperature and short growing season; arctic grassland; soils permanently frozen (permafrost) except for top couple of inches; lichens, grasses, sedges, dwarf woody plants; caribou, arctic hare and fox, lemming

TAIGA:

moist-cool; needle-leaved evergreen (pines, spruces, firs); poor shrub underlayer; moose, squirrel, snowshoe hare

MOIST TAIGA OR TEMPERATE RAIN FOREST:

largely peculiar to west coast - higher temperature than taiga and more moisture than temperate deciduous; fog supplies much of ground moisture; more understory than in taiga; in northeast characterized by hemlock and fir; redwood and sequoia farther south

TEMPERATE DECIDUOUS:

moderate temperature and rainfall; well developed herb and shrub layers; deer, fox, bear, squirrel, mice; forest types: beech-maple, oak - hickory, oak-chestnut, mixed mesophytic (of Appalachian plateau) and pine of southeast coastal plain

GRASSLAND (Prairies):

lowered rainfall, warm temperatures, humic soil; grasses dominant (various life forms); herbs present but relatively unimportant as producers; grazing animals of running (fox, coyote) or burrowing (gopher) type; prairie peninsula extending into Illinois, Indiana and parts of Ohio; a savanna is a tropical grassland with scattered or clumped trees

DESERT:

scarcity of and unevenness of rainfall; plants of three types: annuals (grow and flower only when moisture present); succulents (as cacti); shrubs (small, thick leaves, growth form of numerous branches from a short basal trunk) - animals: arthropods and reptiles largely; kangaroo rat and pocket mouse use metabolic water; camel employs water storage

CHAPARRAL:

a moist desert, milder temperature and more moisture - a "desert with trees"

MOUNTAINS:

complex picture

TROPICS:

most complex

THE ECOSYSTEM

The Concept of Ecosystem

Component Parts

Community Structure and Dynamics

Energy Distribution and Balance Within Ecosystems

Microcosm Approach to Ecological Analysis

ECOSYSTEMS

I. The Concept of Ecosystem

A. Origin and Meaning of the Term

B. Importance of the Ecosystem as an Analytical Unit

C. Types of Ecosystems

D. Arbitrariness of Size and Boundaries

II. Component Parts

A. Biotic Components

1. Types

a. Autotrophs

b. Heterotrophs

(1) Macroconsumers

(2) Microconsumers

2. Stratification of Biotic Components

a. Main Factors Governing Stratification

(1) Availability of Light Energy

(2) Distribution of Organic Matter in Respect to Kind and Size

b. Stratification in Relation to Trophic Levels and Food Chains

B. Abiotic Factors

1. The Medium or Material immediately Surrounding the Organism

a. Nature of Media

b. Contrasting Qualities of Air and Water

c. Pressure

d. Support and Resistence to Motion

(1) Effects on Structure and Size

(2) Effects on Locomotion Through Medium

(3) Passage of Medium Through Organism

(4) The Existence of Plankton

e. Transportation by the Medium

   (1) Sessile Existence

   (2) Distribution by Medium

      (a) Transport by Air

      (b) Transport by Water

f. Abrasive Action of the Medium

2. The Substratum or Surface Upon Which the Organism Rests

   a. Significance of the Substratum

      (1) Needs Provided by the Substratum

      (2) Attainment of the Substratum

      (3) Reactions to the Substratum

      (4) The Variety of Substrata

b. Rock, Sand, and Mud in the Aquatic Environment
  (1) Influence of the Aquatic Substrata

  (2) Breakdown of the Substratum

  (3) Build-up of the Substratum

c. Rock, Sand, and Mud in the Terrestrial Environment
  (1) Influence of the Land Substrata
    (a) Land Surfaces and Animals

    (b) Soil and Its Action on Plants

  (2) Action of Organisms on the Soil
    (a) Abundance of Organisms in Soil

    (b) Soil Formation

    (c) Humus and the Colloidal Complex

    (d) The Soil Profile

3. Water
    a. Water in the Aquatic Environment
        (1) Osmotic Problems

        (2) Limiting Effects of Salinity

    b. Water in the Amphibious Environment
        (1) Swamps and Temporary Pools

        (2) Tidal Zones

    c. Water in the Terrestrial Environment
        (1) Occurance of Water in the Land Environment
            (a) Moisture in Soil

            (b) Moisture in Air

        (2) Microclimates

(3) Meeting the Water Problem on Land

(4) Influence of Moisture on Growth and Distribution

4. Temperature

a. Distribution of Temperature

(1) Extremes of Temperature and of Tolerance

(2) Changes in Temperature

(a) Horizontal Changes

(b) Vertical Changes

b. Biological Action of Temperature

(1) Extreme Temperatures

(a) Maximum Temperatures

(b) Minimum Temperatures

(2) Meeting the Temperature Extremes

(a) Morphological and Physiological Adaptation

(b) Thermal Migration

(3) Action Within Effective Range

(a) Effect of Temperature on Biological Rates

(b) Optimum Temperature

(c) Other Effects of Temperature

c. Action of Temperature on Distribution

(1) Mode of Temperature Limitation

(a) Control by Extremes

(b) Control by Need for Minimum Amount of Heat

(c) Control by Need for Chilling

(2) Results of Temperature Inhibition

(a) Special Cases of Common Boundaries

(b) The Life Zones

(3) Temperature and Moisture Acting Together

5. Light

a. Distribution of Light

(1) Light on Land

(a) Spectral Composition

(b) Intensity of Light

(c) Duration and Amount of Light

(2) Light in Water

(a) Extinction and Modification of Light

(b) Changes In Transparancy

b. Biological Effects of Light

(1) General Effects

(2) Activity and Vision

(3) Orientation

(4) Periodicity

(a) Diurnal Periodicity

(b) Lunar Periodicity

(c) Seasonal Periodicity

c. Ultraviolet light

d. Ecological Aspects of Photosynthesis

(1) Land Plants

(2) Aquatic Plants

COMMUNITY STRUCTURE AND DYNAMICS: FOOD CHAINS AND ENERGY FLOW

It is a pleasant afternoon in August and you are walking through a peaceful meadow. A solitary hawk glides effortlessly on circling updrafts of warm air. A grasshopper, alarmed by violent rustling of your feet among the grasses, goes whirring off on brown brittle wings. Soon you come upon a small meadow pond. Other than the several splashes you heard on your approach which startled the frogs resting on the rocks among the cattails, the systems seems rather quiet, but every member of this pond community is hard at work producing or consuming energy.

Energy first becomes available to the community through the process of photosynthesis. Certainly much photosynthetic activity is taking place because there are many green plants forming zones around the water's edge. Also many forms of algae appear in the water.

Each organism accumulates more energy than it expends, and in so doing, becomes a potential source of energy for some other animal that might use it as food. The grasshoppers certainly are numerous in the neighboring meadow; they should be happy with so much tender grass to eat! Perhaps the frogs here at the pond can include grasshoppers in their daily diet.

Organisms that have no natural enemies, like the hawk you saw on the way, fit into this pattern too, as a large bulk of the energy of this pond system could be traced to their bodies. The hawk soaring in the air is in search of food and as you know, the snake you see at your feet this very moment is food or potential food for the hawk above you.

There are no missing links in nature's food chains. The elimination of any one species may have disasterous consequences for any community. Without the snake at your feet, there would be no beautiful bird to soar on dappled wings above you. Likewise, without frogs, there would be no water snake. That is the very reason that this dry-skinned scalely creature is at the pond's edge. Nature's gifts of fangs and claws were not intended for harming man. It is only through carelessness that man runs into trouble with such creatures which are more often than not, rather timid and would rather flee than take the offensive with man.

The pathways of this constant flow of energy within the pond community from one organism to the next is known as a food chain. Actually "food web" is a better term in that a particular organism may feed on a wide variety of smaller organisms. Hawks feed on mice as well as snakes, and frogs eat all kinds of insects.

Perhaps we can portray this community interaction in a more diagrammatic way as follows:

The material on pages 33-36 may be found

TITLE Round River

AUTHOR Aldo and Luna Leopold

PUBLISHER Oxford University Press

PAGE NO. 159-162

CONSTRUCTING FOOD PYRAMIDS

Required Reading: *Ecology*, Dunn, E., Chapter 3: "Energy Flow and Nature's Metabolism"

I. Determination of Units of Plants Required to Produce One Unit of Herbivore

   A. Choice of Units

      1. Count

      2. Volume

      3. Weight

      4. Fuel Value

   B. Destiny of Food Energy in the Form of Calories

      1. Distribution Along Energy Pathways

      2. The Second Law of Thermodynamics

      3. Assimilation and Maintenance

   C. Ecological Efficiency

      1. Measurement of Ecological Efficiency

      2. Limitations Imposed Upon the Length of Food Chains

QUESTIONS FOR DISCUSSION:

1. How would you propose to measure the ecological efficiency of Daphia as a predator of the alga, Chlamydomonas?

2. Determine the ecological efficiencies of each of the following trophic levels.

Plants		Herbivores		Carnivores		Secondary Carnivores	
20810	8833	3368	1478	383	67	21	6
Entering	Stored	E	S	E	S	E	S

Calculations:

Do your findings support or refute the food pyramid hypothesis?

3. Estimate the reduction in efficiency for a supercarnivore of the 3rd order. Can you think of any such cases in nature?

4. Basically why are food chains usually limited to four stages?

5. How would a food chain be shortened by an animal that is not restricted in its diet? Why would this be difficult if not impossible for most animals? Give examples as to how man has shortened or is shortening the food chain he depends on.

Exercise and Questions

THE NATIONS IN THE TREE

Required Reading: The River of Life, Platt, Rutherford; Chapter 21, pages 283-293

INSTRUCTIONS:

Read The Nations in the Tree through once. Then read it a second time in detail. As you read this interesting work the second time, complete the following:

1. Identify each member of the tree community by name, arranging the names in their proper place in the community's food chain or web. The final product of your work should take on the form of a food chain diagram with arrows to show how each organism is dependent on other organisms as sources of energy in the form of food.

2. On another separate paper, group the organisms into the following categories:

   producers, primary consumers (herbivores), secondary consumers (carnivores), tertiary consumers (if any), and decomposers.

   Actually you can do this when you do the food web above by arranging the names of the organisms into five levels starting with decomposers at the bottom of the diagram and ending with tertiary consumers at the top. Each level should be identified in the margin of your paper if you use this method.

3. On a third paper, describe the ways that each organism is structurally and functionally adapted to its particular place and role in the tree community. Consider for example, what specialized parts each organism has to feed with and to move about with. Also note what patterns of behavior are shown which increases its chances for surviving in such an environment.

4. Does the author tell you anything about the relative numbers, sizes, or weights of each kind of organism that would allow you to construct a hypothetical food pyramid that you think best represents this community? Cite each case and then diagram a food pyramid for this community.

5. What mammals could possibly be introduced into the community that would probably get along very well and yet not seriously alter the community's balance? Identify the animal's place(s) in the food web and food pyramid by including name(s) and arrows with red pencil or pen.

6. According to the author, in what ways does man fit into the system? What specific ways were identified or hinted at by the author which describes or suggests ways in which man interacts with the tree community either beneficially or harmfully? Record each case you find and designate whether the results would be beneficial or harmful to the tree community's balance.

7. The author begins his work with "The tree outside my window . . . ". Do you believe the author considers himself to be a part of the tree community in any way? Could the tree community function and thrive without him? Could he function without the tree community? How do you think the author would react to the tree community's disappearance or decline? How would mankind as a whole be affected if all such plant or animal communities were to disappear?

The material on pages 41-47 may be found

TITLE The River of Life

AUTHOR Rutherford Platt

PUBLISHER Simon & Schuster

PAGE NO. Chapt. 21; The Nations in the Tree

MICROCOMMUNITIES: THEIR STRUCTURE AND SUCCESSION

INTRODUCTION:

Life when observed from our usual point of view consists of relatively large things - like chickadees, oak trees, cattle, cornfields, people, grasshoppers and the like. Some of us may even be aware of some tinier things such as leafhoppers, lace-wing flies, aphids, ants, spiders, water-fleas, hydras, and so forth, but only because we are fascinated with such things and like to look at them. But even though they are less obvious to us, there are microscopic things of all kinds that form complex communities in soil and water which make possible the existence of larger forms of life.

If we reflect for a few moments upon the food webs we studied earlier, we should immediately become aware of the fact that in many food chains, each kind of organism feeds on another kind smaller than itself, and so on down to the very smallest; the protozoans, algae, fungi, and bacteria - various kinds of which we can find living all over the world. These organisms, especially the bacteria and fungi, not only serve as food for other creatures larger than themselves, but also, they participate in breaking down the bodies of plants and animals that have died (or in some cases, may not yet be dead), releasing valuable decomposition products into the soil so that plants may receive nourishment. The many chemical reactions that go on in the soil and water are made possible only by the action of these tiny creatures. Such chemical reactions are important in the development of fertile, healthy soils that function in maintaining proper balance with organic life.

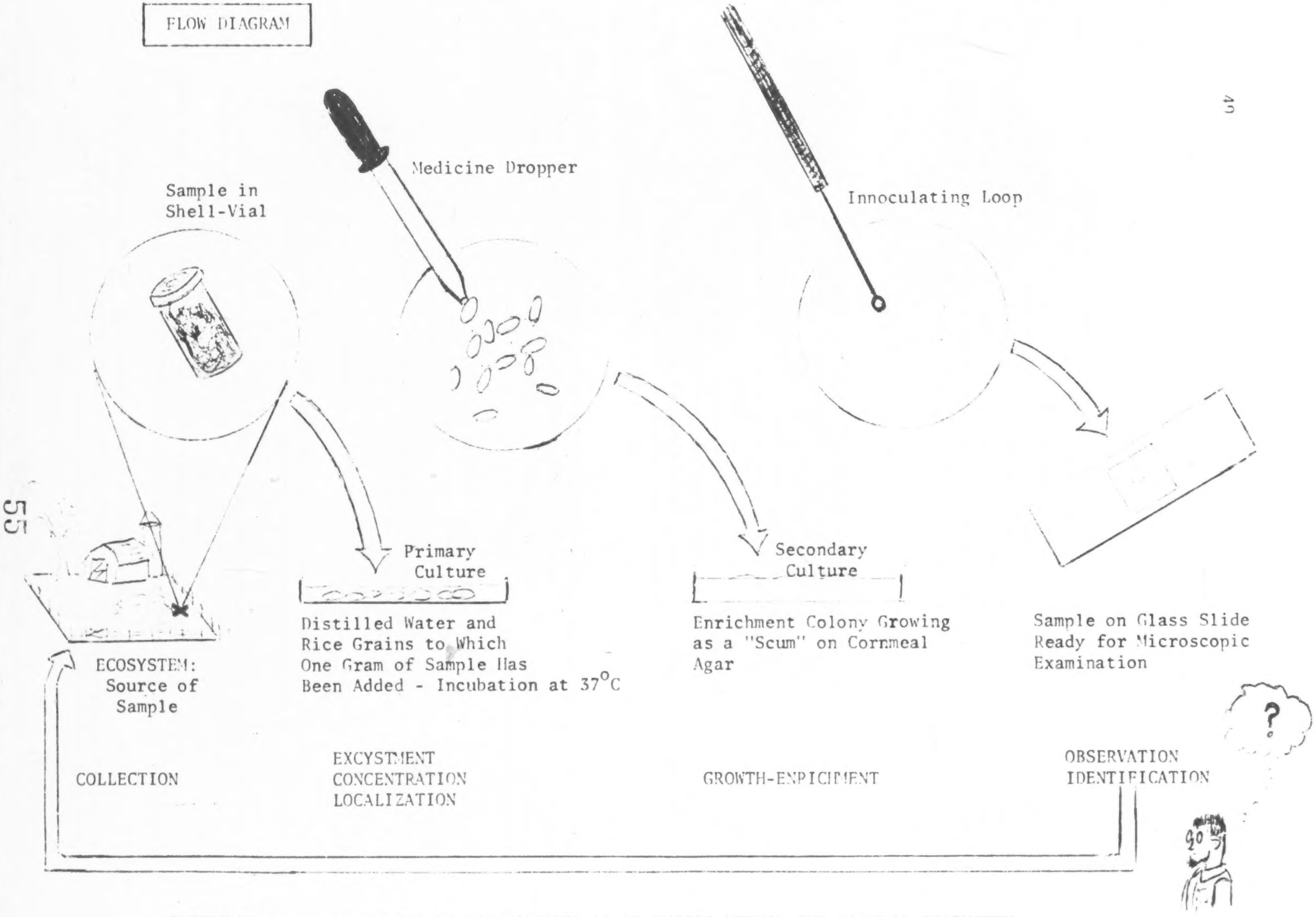
But enough of this. We have read about these matters before. Let it be our purpose to establish some form of contact with these communities of microscopic creatures so we can learn more about them by direct observation. After all, this is our big concern.

Amoebae and many other kinds of protozoa as well as algae, fungi, and bacteria are very common in soils that contain decaying organic matter, and are rather easy for us to collect, culture, and study. However, when we examine ordinary samples under the microscope, we usually find very few of these organisms, if any at all. This is because they are dormant in the form of spores or cysts that are even tinier than they are themselves and are very hard to distinguish from other particles in the soil.

When conditions become favorable, as perhaps after a heavy rain, the tiny creatures excyst and begin active feeding and growing. In the laboratory, we are going to get them to excyst by incubating the samples at 37°C in distilled water containing a few polished rice grains. The emerging microorganisms will collect on the surfaces of the rice grains and feed on the particles of starch they find there. We will gather them up in a pipette, transfer them to an enrichment culture of cornmeal agar where they will grow in large numbers along with the bacteria they feed on.

If you carry out your work carefully, the result will be an exciting micro-ecosystem containing its own characteristic community with pastures of bacteria and herds of amoebae. Such a system will develop and undergo stages of succession very similar to the succession undergone by larger ecosystems.

FLOW DIAGRAM


Sample in
Shell-Vial
Medicine Dropper
Innoculating Loop
Primary
Culture
Secondary
Culture
ECOSYSTEM:
Source of
Sample
Distilled Water and
Rice Grains to Which
One Gram of Sample Has
Been Added - Incubation at 37°C
Enrichment Colony Growing
as a "Scum" on Cornmeal
Agar
Sample on Glass Slide
Ready for Microscopic
Examination
?
COLLECTION
EXCYSTMENT
CONCENTRATION
LOCALIZATION
GROWTH-ENRICHMENT
OBSERVATION
IDENTIFICATION

INFERENCES MADE ABOUT THE MICROCOMMUNITY AS IT EXISTS WITHIN THE NATURAL ECOSYSTEM

COLLECTION OF THE SAMPLE:

You will be given a small vial in which to collect your sample. Your assignment over the weekend will be to collect a single sample of material that you think would be interesting to examine for microorganisms. The material can be either from a terrestrial or an aquatic source, and may be sand, silt, mud, clay, humus, soil, decayed wood or vegetation or anything that fits into any of the categories listed on the DATA SHEET : SOURCE AND ECOLOGICAL CHARACTERISTICS OF ORIGINAL SAMPLE.

Fill the vial completely with the material, replace the cap, and bring it with you to lab on Monday, along with the completed data sheet. You will need a ruler, thermometer, and indicator paper to determine the sample's depth, temperature, and pH at the time of collection. If you do not have these items they may be checked out to you by your instructor.

After you have finished the above work, spend some time mapping out the details of the immediate area from which your sample was taken. Show diagrammatically any buildings, trees, areas of grass covered and bare ground, rocks. bodies of water, etc. Include a compass arrow indicating North. Attach this map to your data sheet.

DETERMINATION OF SAMPLE'S MOISTURE CONTENT:

As soon as you get to lab Monday, remove about half of the sample from the vial and weigh it immediately. Record this weight as "weight of fresh sample". Then place this weighed sample on a piece of filter paper and dry overnight in the drying oven. On the following day, weigh the dried sample recording its weight as "weight of dried sample". The percentage of moisture in the fresh sample is calculated as follows:

$$\frac{\text{weight of dried sample}}{\text{weight of fresh sample}} \times 100 = \text{percent moisture}$$

Record this value on the data sheet for the original sample.

Name ______________________________
Science IIIB Hour _____
Date ______________________________

DATA SHEET: SOURCE AND ECOLOGICAL CHARACTERISTICS OF ORIGINAL SAMPLE

sample number _____ collection site ______________________________

date ______________ time _____ air temp. ______ water temp. _______

soil temp. _______

nature of sample:

aquatic

- __ marsh
- __ bog
- __ swamp
- __ pond
- __ lake
- __ river
- __ stream
- __ spring
- __ puddle
- __ ditch
- __ bird bath
- __ aquarium
- __ other (specify)

terrestrial

- __ field
- __ pasture
- __ prairie
- __ forest
- __ lawn
- __ sand pit
- __ rock bed
- __ bark
- __ rotten wood
- __ other (specify)

predominant particle size

- __ gravel
- __ clay
- __ loam
- __ sand
- __ mud
- __ dust
- __ silt
- __ debris
- __ humus

vertical distribution

Aquatic:

- __ surface film
- __ subsurface open water
- __ subsurface restricted water
- __ surface bottom
- __ subsurface bottom

Terrestrial:

_______________ soil zone

relative fertility
(as determined by growth of
larger plants in collection area)

- __ excellent
- __ good
- __ fair
- __ poor

Depth _____ pH _____
Moisture Content ______ %

large animals frequenting the collection site:

large plants:

small animals (cryptozoa) found hiding within the sample:

small plants:

PREPARATION OF CULTURE MEDIA:

A. Primary Culture

1. Fill a petri dish with 15 milliliters of distilled water and innoculate with one gram of the sample and six grains of uncooked polished rice.
2. Cover and incubate at 37°C for 24 to 48 hours.

B. Secondary Culture (Enrichment Culture)

1. Mix 10 grams of cornmeal with one liter of water and cook for 10 minutes. Then stir in 20 grams of sterile agar powder while the liquid is still hot.
2. Pour the medium into petri dishes, cover, and sterilize at 15 pounds per square inch for 20 minutes.
3. Remove and allow to cool until solid. Then set aside in the refrigerator until ready to use.

CONCENTRATION. LOCALIZATION, AND GROWTH OF EXCYSTED MICROORGANISMS:

A. At the end of 24 hours (or 48 hours - whichever time it takes for a distinct but not unpleasant odor to appear), collect one large drop of material from the interface of the rice and water of the primary culture.

B. Plate out this drop on the surface of one of the cornmeal agar plates and incubate it for 24 hours at 37°C to start your secondary culture.

C. Take a second large drop from the primary culture as you did in Step A, place it on a clean glass slide, cover with a cover slip, and observe for microorganisms. The following instructions will tell you what to look for.

1. Kinds of Organisms: Draw as many different kinds of organisms as you can. Concentrate on the variety of shapes and sizes. Do certain shapes predominate in different parts of the sample you are observing?
2. Abundance of Organisms: Count the number of each kind you find in three different 430X fields and record the average for each kind. How can you distinguish between living and non-living matter on your slide?
3. Motility of Organisms: Compute the proportion of organsims that are motile by recording the average of counts in three different medium power fields. Do this for each kind of organisms. Express your results as percent motile. Are the types of movement the same for all the organisms on your slide?
4. Size of Organisms: Exact measurement of the size of creatures, be they large or small, often is necessary before they can be accurately identified. Of course, it is hard to place a ruler

against a microbe in order to determine its size, so techniques have been devised to make this possible. One of these techniques makes use of a metal disc, with seven teeth, which fits into the eyepiece of your microscope and looks like the drawings below.

All you need to know before you can use the disc is the distance between the teeth so that you can use them as you would a "microruler". These distances, and the magnification at which they have been calculated, are as follows:

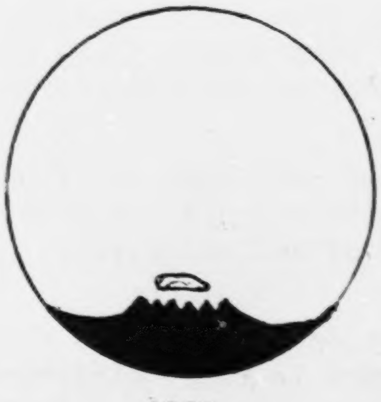
MAGNIFICATION	DISTANCE BETWEEN TEETH (IN MICRONS)
100X	50
430X	12
970X	5

Now you are ready to measure the size of the microbes you have sketched, next to the teeth of the discs in the drawings below. Write the size of the microbe illustrated in the space provided below each drawing.

Make the measurements before answering the following questions and compiling your data on the data sheets.

Are any organisms on your slide too small to be distinguished by the medium power lens? How big is the biggest kind? Record the size of each kind of organisms in microns on your data sheet.

5. Color of Organisms: Of the colors represented, does any one predominate? If so, what color? Identify the color of each kind of organism on your data sheet.


100X

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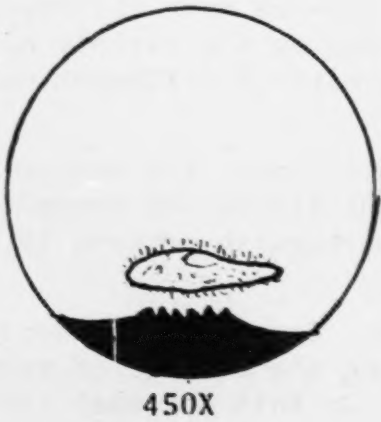
450X

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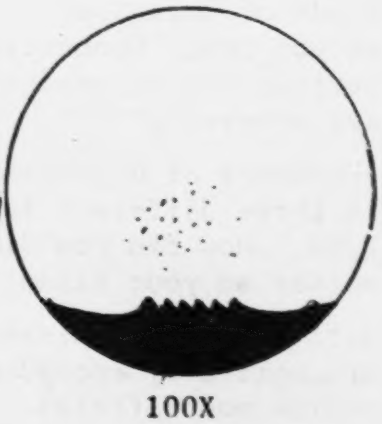
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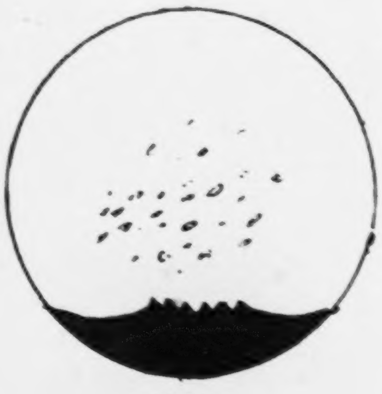
450X

______

RECORD ALL YOUR OBSERVATIONS OF THE CONTENTS OF THE DROP ON THE DATA SHEET FOR THE PRIMARY CULTURE. A DRAWING FOR EACH KIND OF ORGANISM SHOULD BE INCLUDED ON A SEPARATE PIECE OF PAPER AND SUBMITTED ALONG WITH YOUR NUMERICAL DATA.

Data Sheet

Name ____________________
Science IIIB Hour ___
Date ____________________

PRIMARY CULTURE

from original sample number _____ which was collected on __________ (date)

starting date of primary culture _____ incubation was for __ hours at ___ degrees

condition of culture at the end of incubation time:

odor: (check only those that best describe the odor)

__ pleasant
__ unpleasant
__ musty
__ irritating
__ penetrating
__ foetid
__ fresh
__ fruity
__ putrid
__ sour
__ ripe
__ pungent
__ spicy
__ rancid

general appearance of rice grains:

relative trubidity of the water:

__ high-heavy milky white
__ medium-cloudy, nearly opaque
__ low-only slightly cloudy, rather transparent
__ negligble-clear or very nearly so

pH:

Microorganisms Identified at the End of the Incubation Period:

Drawing Number	Name	Relative Abundance	Motility	Size	Color	Notes on Behavior

D. Twenty-four hours later, collect a small sample of material from the surface of the secondary culture plate with a bacteriological loop. Smear this sample into a drop of distilled water on a clean glass slide. Cover with a cover slip. Search for microorganisms as you did with the drop taken from the primary culture. Repeat observations at 48 hours; 4 days; 7 days; 10 days; and 14 days. completing the respective parts of the data sheet for the secondary culture.

E. When all work is complete and all data recorded, summarize the results of this work graphically by completing the Profile Chart.

Data Sheet

Name _______________________
Science IIIB Hour __
Date _______________________

SECONDARY CULTURE

from original sample number ___ which was collected on ____________ (date)

starting date of primary culture ______________ incubation period ___ hrs.

starting date of secondary culture ____________ incubation period ___ hrs.

condition of culture after _____ hrs at 37°C:

_____ relative moisture content: (use numbers from key on reverse side)

_____ odor: (use descriptive terms from Data Sheet for Primary Culture)

general appearance of culture: (describe texture, color, size, thickness of any colonies appearing as films or scums over the agar surface):

_____ pH:

_____ relative turbidity (of one large drop of water to which has been added a loopful of matter from agar surface - then evaluate as for Primary Culture):

Microorganisms Identified at the End of Period:

Drawing Number	Name	Relative Abundance	Motility	Size	Color	Notes on Behavior

KEY TO RELATIVE MOISTURE CONTENT

5 points - large pools of condensed water on underside of cover and on agar surface - water runs to side of dish on tipping

4 points - medium to small beads of water condensed on cover and agar surface but not enough to run to side of dish on tipping

3 points - moisture on agar surface detectable only by sliding a bacteriological loop over the surface - loop should slide freely revealing slippery surface

2 points - surface beginning to dry - colonies hold the only free moisture to be found - agar shows no signs of shrinkage as yet and still is holding some moisture

1 point - agar beginning to pull away from the sides of the dish - shrinkage due to water loss from agar - colonies still may retain some moisture in places but are very replete

SIMPLE KEY TO MICROBIAL GROUPS*

1 a.	cells colored	2
1 b.	cells not colored	6
2 a.	cells larger than 3 microns in width with chloroplasts and defined nucleus	3
2 b.	cells smaller than 3 microns in width; lacking chloroplasts and a defined nucleus	5
3 a.	chlorophyll - green in color	green algae
3 b.	other than chlorophyll - green in color	4
4 a.	red, or dull purple-green; multicellular	red algae
4 b.	yellow, or golden-brown; unicellular or in chains	diatoms
5 a.	blue-green or blue; often filamentous; sometimes embedded in clear jellylike material	blue-green algae
5 b.	pale green or purple, solitary or in small chains; (not easy to see in pond water)	purple bacteria
6 a.	cells lacking rigid walls; unicellular; usually motile, larger than 5 microns	protozoa
6 b.	cells with rigid walls; unicellular or multicellular	7
7 a.	cells less than 3 microns in width	bacteria
7 b.	cell more than 3 microns in width	fungi

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* Microbes, Their Growth, Interpretion, and Nutrition

THE LAWS OF THERMODYNAMICS

Required Reading: The Laws of Disorder, Lotter, George; Parts I, II, III; May, June, July issues of Chemistry, 1968

I. The Conservation of Energy

   A. Review

   B. Equivalence of Energy

II. Disorder vs. Order

   A. A Need for Another Law

   B. Probability

   C. Entropy and the Second Law

III. Consequences

   A. Seeming Violations

   B. Heat Death

ENERGY FLOW AND NATURE'S METABOLISM

Required Reading:	Ecology, Odum, E., "Energy Flow and Nature's Metabolism", Chapter 3
	Cell Structure and Function, Loewy and Siekevitz, "Life and the Second Law of Thermodynamics", Chapter 2

I. Energy and Matter

  A. Energy-Dependent Factors Affecting the Density of a Given Species and Rate at Which it Lives Within Its Ecosystem

    1. Rate of Energy Flow in the Form of Food and Sunshine

    2. Rate of Turnover of Matter in Biogeochemical Cycles

  B. The General Nature of Energy Flow in Ecosystems

    1. Non-Cyclic

    2. Unidirectional

    3. Input, Utilization and Loss, Output

  C. The One-Way Flow of Energy as the Result of the Operations of the Laws of Thermodynamics

    1. Life and the Laws

      a. The First Law: Conservation of Energy Within the Ecosphere

b. The Second Law: Its Relationship to the Stages of Succession of Ecosystems

c. The Third Law: The Procession Towards Disorder and the Eventual Disappearance of Life

2. The Possibility of a "Fourth Law"

a. A Unique Property of Living Matter

b. Evolution of a Bios of Increasing Complexity

c. Reduction of the Rate at Which Free Energy Becomes Degraded

D. The Interaction of Energy and Matter Within the Ecosystem

1. Interacting Functions

a. One-Way Energy Flow

b. Cycling of Matter

2. "Tangential" vs. "Radial" Evolution

3. Applicability to All Environments

E. General Characteristics of the Energy Flow Diagram for Ecosystems

1. Applicability in Principle to All Ecosystems

F. Requirements of a Model for Energy Flow Within an Ecosystem

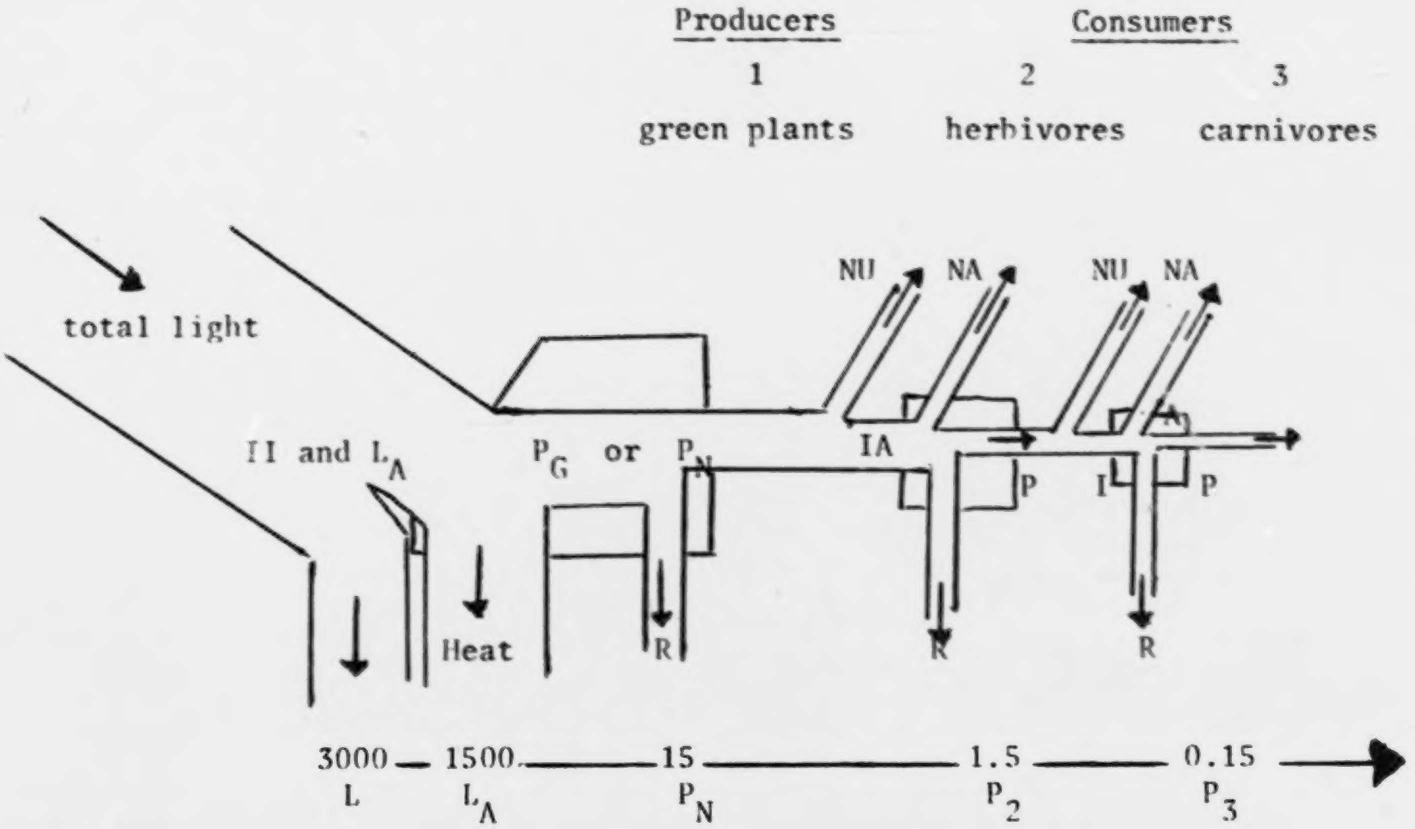
1. Applicability in Principle to All Ecosystems

2. Depicts General Characteristics of Food Chains and Food Pyramids

3. Accounts Quantitatively for Energy Balance

a. Input

A SIMPLIFIED ENERGY FLOW DIAGRAM


Producers
Consumers
1
2
3
green plants
herbivores
carnivores
total light
H and L_A
Heat
P_G or P_N
R
NU
NA
IA
P
I
R
NU
NA
P
R
3000 L
1500 L_A
15 P_N
1.5 P_2
0.15 P_3

Key to Energy Flow Diagram:

Boxes: represent the standing crop of organisms (1. producers or autotrophs; 2. primary consumers or herbivores; 3. secondary consumers or carnivores)

Pipes: represent the flow of energy through the biotic community

L : total light

L_A : absorbed light

P_G : gross production

P_N : net production

I : energy intake

A : assimilated energy

NA : non-assimilated energy

NU : unused energy (stored or exported)

R : respiratory energy loss

Chain at bottom of diagram: indicated the order of magnitude expected at each successive transfer starting with 3000 kilocalories of incident light per square meter per day.

(diagram from Ecology by Eugene Odum, page 38)

By now you have come to realize that a community involves very complicated relationships. Individuals react together and form a population. These individuals also react with their environment. This is complicated in itself. But, at the same time, all the populations are reacting to one another to form a community. The community further reacts with such physical factors of the environment as temperature, soil, and rain. All the living and nonliving things in a community and their interactions with one another make up an ecosystem. The complexity of an ecosystem is further brought out through the study of food chains and food webs. Everything is reacting with everything else and influenced by everything else.

Natural ecosystems are therefore very difficult to analyze. Attempting to resolve this problem, environmental scientists have resorted to the use of microcosms - and this is what we are going to study in this next section.

THE MICROCOSM APPROACH TO ECOSYSTEMS ANALYSIS

Recommended Reading: Bull. Sci. Acad. Peoria, Forbes, S.A., 1887, "The Lake As A Microcosm", reprinted Ill. Nat. Hist. Surv. Bull. 15, pages 537-55, 1925

Ecology 11, Richardson, R.E., 1930, "Notes on the simulation of natural aquatic conditions in fresh water by the use of small non-circulating aquaria", pages 102-109

I. Introduction

A. The Idea of Microcosm

B. Historical Development of the Idea

C. Misconceptions about the Nature of Microcosms

II. Advantages of the Microcosm Approach Over the Ecosystems Approach

A. Ecosystems

1. Problems Concerning Boundaries

2. Problems Concerning Size

3. Problems Concerning Variability

a. Light Intensity and Duration

b. Temperature Averages and Extremes

c. Material Suspended or Dissolved in the Fluid Medium

d. Conditions of Export and Import of Non-Living Materials and Biota

B. Microcosms

1. Problem of Boundaries

2. Problem of Size

3. Problem of Variables

4. Problem of Divergence

5. Succession Within the Microcosm

III. Criticism and Defense of the Microcosms Approach

A. Problem of Differences Between Microcosms and Their Parent Communities

B. Logical Resolution of the Problem of Differences

IV. Means of Establishing a Microcosm

A. Collection of Components

B. Spatial Arrangement of Components within the Microcosm's boundaries

C. Maintenance of Physical and Chemical Factors

D. Period of Succession

E. Criteria for Balance

F. Import - Export

G. Effects of Altering Conditions at Any Given Time

V. Types of Research Possible with Microcosms

A. Productivity and Theoretical Ecology

B. Radioactivity and Tracer Study

C. Biogeochemical Cycles

D. Life Support Systems and Sanitary Engineering

E. Instructional Applications

F. Miscellaneous Uses

MAN IN THE BIOSPHERE

The Ecology of Man, the Animal

THE ECOLOGY OF MAN, THE ANIMAL

Required Reading: Bioscience, "The Ecology of Man, The Animal", Charles Kendreigh, August 1965, pages 521-523

"The Aging Great Lakes", Powers and Robertson, Scientific American, November 1966, offprint #1056

QUESTIONS FOR CONSIDERATION:

1. In a great many ways, man is an organism among other organisms. What specialized traits does man share with other animals that enables him to carry out various complex activities and behavioral patterns as they do?

2. What was the author's purpose in calling our attention to these traits?

3. In what ways is man unique among other organisms?

4. Essentially why must man fit himself harmoniously into the ecosystems of other animal species?

5. What reason have we to regard ourselves as relatively new creatures on this planet? Do we have any reason to regard ourselves as permanent residents of this planet? Why?

6. What does the author mean by the phrase, "the process of speciation"?

7. In what ways is civilization chiefly responsible for interrupting the process of speciation in man? Is the interruption of this process necessarily disadvantageous? Discuss fully.

8. Consult ecology texts and identify the meanings of the following laws:
    a. Shelford's Law of Tolerance -
    b. Liebig's Law of the Minimum -
    c. Blackman's Limiting Factors -

9. In what ways has man evaded the operations of these laws in regard to his own existence? Identify the condition by which these laws inevitably become applicable to man.

10. What factors have permitted man to become an ecological dominant in the biotic community?

11. Is man's dominance throughout the biosphere complete and infallible? Will it ever be?

12. Describe the nature of the ecosystem that man has created for himself. Include his ways of maintaining this ecosystem in regard:

    a. to the kinds of producers he has established in it -

    b. his ways of eliminating competitive consumers -

    c. his ways of replenishing nutrients cycles for continued productivity-

13. With each additional link in the food chain through which energy and nutrients are transmitted, there is a loss of some 80 to 90 percent. How do you account for these tremendous losses?

14. What means would you suggest be employed in order to reduce such losses?

15. By shortening food chains, man is able to take full advantage of the productivity of the land. How has man done this in densely populated parts of the world? HINT: Compare food chains for people in India and Asia with those for people in the United States and Europe. For each case, how are they established and maintained?

16. How would you react to and be affected by living in an area of high population density where food chains are shorter than the one you are now accustomed to, were the only ones that supported the people?

17. What disadvantages are introduced by shortening food chains? What advantages?

18. What factors commonly set the upper limit to the size of any population?

19. What difficulties are encountered in deciding how much space is required for man to live? Do you think that the amount of space needed by a person who had been raised in the country would vary much from that needed by a person raised in the city?

20. In what ways that relate to his present population size has man been able to control his environment?

21. Does the author believe that war is a factor limiting the size of human populations? What are his views and opinions concerning the continuation of wars in the future?

22. What factors account for the new accelerating phase in the growth curve for the human population? How does the author propose that this rapid growth be checked? Does it have to be checked? Why?

23. The author ends on the optimistic note that man has been blessed with an intelligence far above that of other animals. Has modern man achieved a level of coexistence with his own kind and with other creatures that reveals this to be the case? Cite specific cases where man fails to support his claim to being that blessed creature who is capable of governing his actions through the use of intelligence and reason.

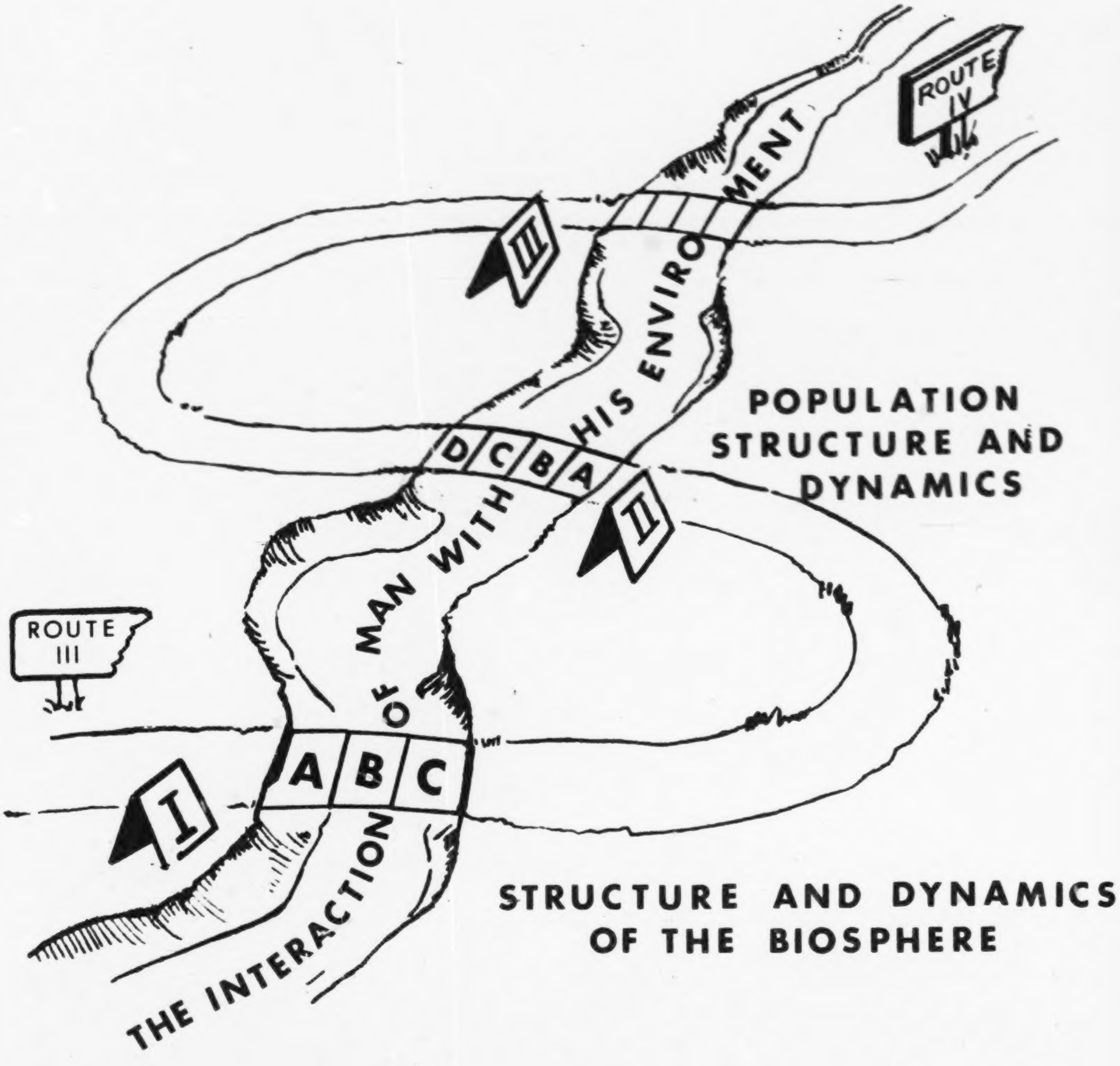
The material on pages 71-73 may be found

TITLE   The Ecology of Man

AUTHOR   S. Charles Kendeigh

PUBLISHER   Bioscience   August, 1965

SCIENCE IIIB


ROUTE IV
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D C B A
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ROUTE III
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I
THE INTERACTION
STRUCTURE AND DYNAMICS OF THE BIOSPHERE

A. STRUCTURE AND ORGANIZATION

B. THE FUNCTIONING OF POPULATIONS

C. POPULATION GENETICS

D. HUMAN POPULATIONS

Population Structure and Dynamics

STRUCTURE AND ORGANIZATION

The Individual and Species Concepts

The Population and Community

POPULATION: STRUCTURE AND DYNAMICS

A. Structure and Organization

1. The Individual and Species Ideas

Definition

2. The Population and Community

Definition

Communities are organizations of living organisms, some stable and some in transition. Stable communities exist in equilibrium with their environment and any change in the environment may result in a change in the many populations within the environment. This is true because individuals and species compete with each other for water and nutrients (or food), light, and space, and the margin of superiority which one species enjoys over another may be very slight. The activities of man frequently disturb delicate natural equilibria, and the result is change in plant and animal populations or in the creation of blighted or polluted areas. Pollution can profoundly alter man's life, even making it ultimately impossible.

Living things and their environment influence each other, none lives without constantly influencing its surroundings.

Biological interactions involving man are the same sorts and subject to the same principles as those in non-human communities.

THE FUNCTIONING OF POPULATIONS

Population Growth and Size Factors

The Ideas of Malthus

Population Interactions

Periodism

The Functioning of Populations

INTRODUCTION:

The populations of the hundreds of thousands of living species which inhabit the surface of the earth are limited. The limiting factors for any species are numerous and interrelated, but clearly a major one is the food supply. Animals will live, grow, and reproduce only if they can eat. If the food supply disappears, the animals will die.

Since the primary source of animal food is plant life, the total amount of life which can exist in the animal world is fixed by the rate at which photosynthesis takes place. The world wide rate at which photosynthesis takes place is in turn fixed by such factors as the amount of sunlight, seasonal variation in temperature, and the availability of water and nutrients necessary to plants, such as nitrogen, phosphorus, and sulfur.

Most photosynthesis takes place in the oceans and thus there is more life in the oceans than on land. On the surfaces of most seas we find countless microscopic plants called algae. Microscopic animals feed upon the algae and upon one another. In turn, larger animals feed upon the mixture of microscopic plants and animals. The total amount of animal life in the oceans, including all whales, fish, mollusk, protozoa and others is thus fixed by the rate at which the ocean plant life grows. A similar situation exists on the land areas of the earth.

Within the animal world there is increasing fluctuation. Populations of the individual species increase and decrease; new species appear and disappear. Whether or not a species of animal continues to exist depends upon many factors. Ultimatley, however, continued existence of a group depends upon the specific rate of production of young and upon the fraction of the young which survive through the breeding age. For a species of animal equally divided between males and females, the population will be stable if two young members enter the breeding period for every two who leave it. If the number entering drops appreciably, the population of the group as a whole will drop rapidly.

In a given group of animals, the fraction of young which survives to breed depends upon many factors in addition to the food supply and the birth rate. The offspring arising from species that watch over and care for their young until maturity is reached, stand a better chance of surviving to breed than do the offspring of other species. The existence of predators decreases the chances of survival. Frequently, within the species, there are threats to existence, involving cannibalism or competition for mates.

The mathematics of the interrelationships between living species is extremely complicated if more than two species are involved. Most living creatures live in complex environments and as a result the interrelationship between a given species and the living things about it are manifold.

Wherever an existence can in some manner be eked out, an organism can be found which manages to take advantage of the possibility. At any time, every possible niche of life is filled and the life within each niche is related to the other living groups about it. We see, in the oceans and on the land, vast systems of living things, in each of which the various species are dependent upon one another for their existence. A given system might include a diversity of plant life, bacteria, insects, fish, amphibians, reptiles, and mammals, all living in harmony. While such systems are frequently fairly stable and can exist for long periods of time, if any one of the component groups is disturbed appreciably, all of the other will be affected.

1. Population Growth and Size Factors

   a. Birth (Natality)

   b. Death (Mortality)

   c. Survival Curve

   d. Migration (in and out)

   e. Density defined:

The population density of any kind of organism in any given space at any given time is the result of the numerical relations among mortality, natality, immigration rate, and emigration rate. We may call these four rates the "determiners" of population density. In any study of population change, the biologist must consider these four rates and in any experimental study of populations, these determiners must be considered as variables.

It should be clear that any reference to the size of a population has meaning only in terms of space. If we are referring to changes in the size of a population within a given space, then we are referring to a density change, even if we have neither measured the space nor expressed the density numerically. The phrase "population density" is often abbreviated to "population".

The material on pages 77-78 may be found

TITLE The Challenge of Man's Future

AUTHOR Harrison Brown

PUBLISHER The Viking Press

PAGE NO. 5-7

A MONUMENT TO THE PASSENGER PIGEON

On May 11, 1947, in Wyalusing State Park, the Wisconsin Society for Ornithology dedicated a monument to the extinct passenger pigeon. A thoughtful conservationist wrote down his interpretations of this event.

We have erected a monument to commemorate the funeral of a species. It symbolizes our sorrow. We grieve because no living man will see again the onrushing phalanx of victorious birds, sweeping a path for spring across the March skies, chasing the defeated winter from all the woods and prairies of Wisconsin.

Men still live who, in their youth, remember pigeons. Trees still live who, in their youth, were shaken by a living wind. But a decade hence only the oldest oaks will remember, and at long last only the hills will know ...

For one species to mourn the death of another is a new thing under the sun. The Cro-Magnon who slew the last mammoth thought only of steaks. The sportsman who shot the last pigeon thought only of his prowess. The sailor who clubbed the last auk thought of nothing at all. But we, who have lost our pigeons, mourn the loss. Had the funeral been ours, the pigeons would hardly have mourned us. In this fact, rather than in Mr. DuPont's nylons or Mr. Vannevar Bush's bombs, lies objective evidence of our superiority over the beasts.

-ALDO LEOPOLD, in *A Sand County Almanac* (New York: Oxford University Press, 1949), pp. 101, 108-110.

a. Competition

Materials and Energy - It is important to recall that the energy flow through a biological community is a one way process and not a cycle. The energy flow becomes less and less available to organisms as it moves through the system. This requires a constant renewal of energy - and from only one significant source, the sun. In terms of population relationships, the, the size of producer populations (the capable of converting solar energy to forms usuable by other organisms), will determine the size of all consumer populations.

Food Chains

b. Predation

Undeniably the means of subsistence is the ultimate limit on any population, but in natural communities animals rarely live up to this limit. There usually seems to be plenty of food for all and death through starvation is probably rare.

Where a population does live up the limit of the means of subsistence, catastrophe is likely to result. The incredible hordes of migratory locust, which at times strip the countryside of every green thing in various parts of the world, are a case in point. Locust plagues have been recorded in Egypt and Assyria since the beginning of written history. Disastrous insect outbreaks are often the consequence of man's interference with the ordinary balance of natural communities, but this can hardly be the case with locusts.

Research indicates that there may be two forms of locusts - migratory forms, or those raised under crowded conditions and solitary forms or those raised in isolation. The solitary forms live dispersed in grasslands slowly building up in abundance until, at some stage in crowding, the restless, gregarious migratory form appears and the great hordes of insects, darkening the sky, take off to devastate any vegetation in their paths. The swarms may fly out to sea and they almost always end in some environment where the species cannot survive. New swarms are then built up from individuals that stayed behind in the homeland. The mass suicide clearly serves as a final limit to population growth.

The mass suicide of these insects brings to mind the famous case of the Norwegian lemmings. Lemmings are small, mouselike rodents that inhabit the subarctic regions of both hemispheres. Most species show rather regular cycles of abundance with peaks at intervals of three or four years. The Norwegian lemmings have attracted particular attention because in years of abundance they pour down from the mountains toward the sea through farms, villages and towns - indifferent to all obstacles.

There have been many laboratory studies of the effect of crowding on animals. Overcrowding results in a slowed rate of growth and in undersized, weak adults - easily enough explained in terms of food shortage. But even when provision is made so that an abundance of food is always available, there may be striking changes in behavior and physiology. Most of the studies have been made with rodents and in these animals, the overstimulation under crowded conditions results in a disruption of the usual endocrine balance, causing most notably, an enlargement of the adrenal cortex. The consequences are diminished reproductive functioning in both males and females, inhibition of growth, increased susceptibility to disease, and so forth. The endocrine changes under caged conditions are clear; whether comparable changes occur under crowded condition in the wild is not well established, although it would seem a likely explanation of abnormal behavior. Observations made under experimental conditions must always be checked with studies in the field if they are to be correctly interpreted.

Probably the best known studies of the behavior of mammal populations under confinement are those carried out by John Calhoun with the Norway rat. In general, Calhoun and others have found that under crowded conditions, but with ample food available, behavioral changes occur that greatly reduce reproduction. The most striking cases involve the formation of what Calhoun has called "behavioral sinks". In experiments in which a large enclosure is subdivided into pens with restricted access, dominant males may establish more or less normal reproductive relations in some pens, while the other pens will be occupied by the outcasts, who show various abnormal behavioral patterns - who show "social pathology".

Females in a behavioral sink become shoppy nest builders or fail to make nests at all; litters are aborted or young neglected, making for a high infant mortaility. Some males become extremely phlegmatic, losing all interest in sex or in fighting. Others become hypercetive - the "probers" - attempting to mate with other males or with females not in estrus. They also tend to be cannibalistic, eating the abandoned young.

Thus the "vice and misery" of the Malthusian proportions develop in rat populations as well as in humans. Invariably one compares rats in a behavioral sink with humans in a crowded ghetto. Certainly people often behave very much like rats, although certainly the differences outweigh the simalarities.

The material on pages 83-87 may be found

TITLE How Much Space Does A Man Need?

AUTHOR John Lagemann

PUBLISHER Reader's Digest Association, Inc.

Aug. 1967

Periodism

a. of Populations and Communities

b. Geologic

Populations and communities, wherever they may be, are dynamic groups living in (and forming part of) environments that are also dynamic; they change constantly, from hour to hour, season to season, year to year, and epoch to epoch. The rhythm of day and night is reflected in the activities of all communities. Here in the Temperate Zone we are all familiar with the dramatic cycle of the seasons: the fall of leaves, migrations of birds, disappearance of insects, and the seemingly closing down of nature's business in the fall, the quietness of winter, the rebirth of spring, and the bustling activity of summer. The cycle appears to annually repeat itself but never exactly. One rare day in July may be much like another a year hence, but as the years pass they bring slower changes. The student who traces the larger history of the earth finds great changes in matters of the appearance, rise, fall, and disappearance of specific populations and communities.

POPULATION GENETICS

Genetic Equilibrium

Evolution in Genetic Equilibrium

INTRODUCTION:

The gene as the ultimate source of biological characteristics and the sea of organic change, or mutation, was recognized soon after 1900 when the genetic principles of Mendel were rediscovered, but not until population genetics emerged as a special development did the full impact of this new discipline modify profoundly the basic preoccupation of students of evolution. For population genetics took as one of its principle tasks the analysis of microevolution by studying the genetic dynamics of populations. And since the cutting edge of evolution is at that level, the insights provided by this new approach have both enriched evolutionary concepts and focused attention on its functioning mechanisms.

1. Genetic Equilibrium
   a. Gene Pools

   b. Hardy-Weinberg Law

2. Evolution Or Changes in Genetic Equilibrium

EVOLUTION - Our new knowledge of gene structure promises to fill an important gap in our understanding of evolution. We can now define life in objective terms - ability to replicate in the manner of DNA, and to evolve through mutation and natural selection. Biochemists may, before long, be able to duplicate in test tubes the conditions under which "living" molecules arose on earth a few thousand million years ago. Understanding of the nature of life is thus replacing mystery.

We now see evolution as a continuous process by which elements evolved from hydrogen, inorganic molecules, and "organic" molecules arose; these interacted to produce replicating systems like DNA; virus-like systems evolved into cellular forms; these in turn evolved into multicellular plants and animals; and finally man arose, with his capacity for adding cumulative cultural inheritance to the mechanical biological inheritance of his remote ancestors. All this is now believed to be an orderly process in which the individual steps are not unlike those we observe today in experimental organisms. Separate mutational steps occur inevitably and those that confer selective advantages to the individuals that carry them are multiplied preferentially. Organic evolution, though unpredictable in direction, is bound to occur when the conditions are favorable.

a. Mutation

b. Natural Selection

c. Natural Selection in Human Populations

EVOLUTION BY NATURAL SELECTION OF HERITABLE VARIATIONS

An example of the relationships between natural selection and mutation is a condition known as sickle-cell red blood cells that occurs among West African indigenes. The gene causes formation of abnormal hemoglobin, the molecules of which attach themselves to one another end to end, thereby distorting the cells and causing them to look like sickles. These cells are easily destroyed, and in homozygotes (individuals that inherited only the sickle-cell gene) under conditions of oxygen deficiency, this results in anemia, thrombosis, and death. It is not surprising that the gene is recessive. On the other hand, this abnormal hemoglobin prevents the entry in the red cells of the parasite *Plasmodium falciparum*, which is responsible for a type of malaria. In regions where malaria is endemic, an equilibrium is set up between the number of normal homozygous individuals liable to die of malaria to the number of individuals homozygous for the sickle gene that are liable to die of thrombosis. The heterozygous individuals (who have both normal and sickle cell genes) get the best of both worlds, for they are protected from both dangers. But their genetic constitution makes inevitable the production of homozygote offspring of both kinds, who will pay their different kinds of penalty.

In West Africa, the sickle gene is present in 20 percent of the population. With this percentage, four out of five homozygous sickle children die. The descendants of these populations in the U.S. where there is no endemic malaria, show only 9 percent with sickle genes. This example shows how natural selection, opportunistically, can convert a lethal gene into one that confers survival value under certain ecological conditions. Furthermore, it provides a case of the special advantage enjoyed by heterozygotes, and shows how the percentage of a gene in a population can become changed. The latter is of particular importance because, as a result, evolution can also be defined as a statistical change in a gene pool of a population.

Population Structure and Dynamics

HUMAN POPULATIONS

Basic Ecology of Man

Demography, Past and Present

Human Populations

1. Basic Ecology of Man

    a. Primitive Man and Environment

    b. Cultural Modification of Human Ecology

    c. Environmental Modification

Required Reading Resource: The Human Population, Deevey, S.A., Reprint Sept. 1960, #608

2. Demography, Past and Present

   a. Definition

   b. Growth of Human Population

   c. How many men can the Earth support?

GENETIC KNOWLEDGE AS A RESOURCE

Man's spectacular succes in conquering his environment, in increasing his food supply, and in multiplying his numbers is itself evidence of the selective advantage of intelligence and the transmission of accumulated cultural knowledge. We now direct the evolution of the plants and animals that serve our many needs. Our ability to do these things ever more successfully and efficiently rises steadily. We could in fact apply the knowledge we have attained in directing our own evolutionary futures . . . but unless we were to do this with a great deal more wisdom than we have so far demonstrated, we would surely fail miserably if we tried.

With the present rates of population growth, something will have to happen before too many generations, If we do nothing - which, even though negative, is a decision - populations will surely go on increasing at rates that will still further tax the civilizations that feed, clothe, and house them. In addition to a general increase in numbers, there will inevitably be changes in population composition, for at no time in the foreseeable future will different segments of the human population reproduce at equal rates. If the A's outbreed the B's and C's and D's, will it be because the A's are better fitted to direct man's future biological and cultural development? Or will it be because the A's are merely less responsible in controlling their numbers? The long-term consequences will be very different in two cases.

Questions of these kinds are at once vitally important and enormously difficult to answer. They go far beyond science in their implications. Biology, including its applications in agriculture and medicine, will help in important ways to find the answers. Geneticists will have a great deal to say about such things as the necessity of genetic diversity in populations, the biological consequences of interpopulation mixing, and the effects of increased mutation rates that will result if exposure to artificial radioactivity is significantly increased over its present levels. But what is to be done, once answers to all these questions begin to be available, will have to be decided by society as a whole, and on a world-wide basis. Such decisions will inevitably require important modifications of present ways of thinkings about social problems. For example, can we go on indefinitely, defending as a fundamental freedom the right of individuals to determine how many children they will bear, without regard to the biological or cultural consequences?

This paper is from a symposium sponsored by Resources for the Future. It has now been published in a book entitled Science, Resources, and Society.

THE IMMEDIATE PROBLEM AND SPECTRE OF TROUBLE

The tensions which exist in the world today are greater than at any previous period of history. At one end of the scale there is the well-fed, well-clothed, and well-housed minority, which guards jealously its present accumulation of wealth--parts of whicn, however, are already beginning to decay. In the middle of the scale is another minority, which, as the result of prodigious efforts, has undergone partial industrialization. The people of such regions are still poor, some are enormously overcrowded, and all are prepared to take practically any step, no matter how violent it may be, which might enable them to complete the transition. By contrast with the people of the wealthy minority, the people of the transition areas have relatively little to lose and much to gain by violent action. And at the bottom of the scale of wealth is the over-whelming majority of disease-ridden, hungry, under-privileged persons who have been exploited by the privileged minority and who cast envirous eyes upon the wealth of Western nations. The people who belong to the underprivileged majority are restless, and in many regions of the world they are in active revolt. Industrialization is beginning to spread to such areas with consequences which can at present be only dimly perceived.

It is clear that the future course of history will be determined by the rates at which people breed and die, by the rapidity with which non-renewable resources are consumed, by the extent and speed with which agriculture production can be improved, by the rate at which underdeveloped areas can industrialize, by the rapidity with which we are able to develop new resources, as well as by the extent to which we succeed in avoiding future wars. All of these factors are interlocked.

The graphs on page 98 may be found

TITLE Biological Science - Patterns and Processes

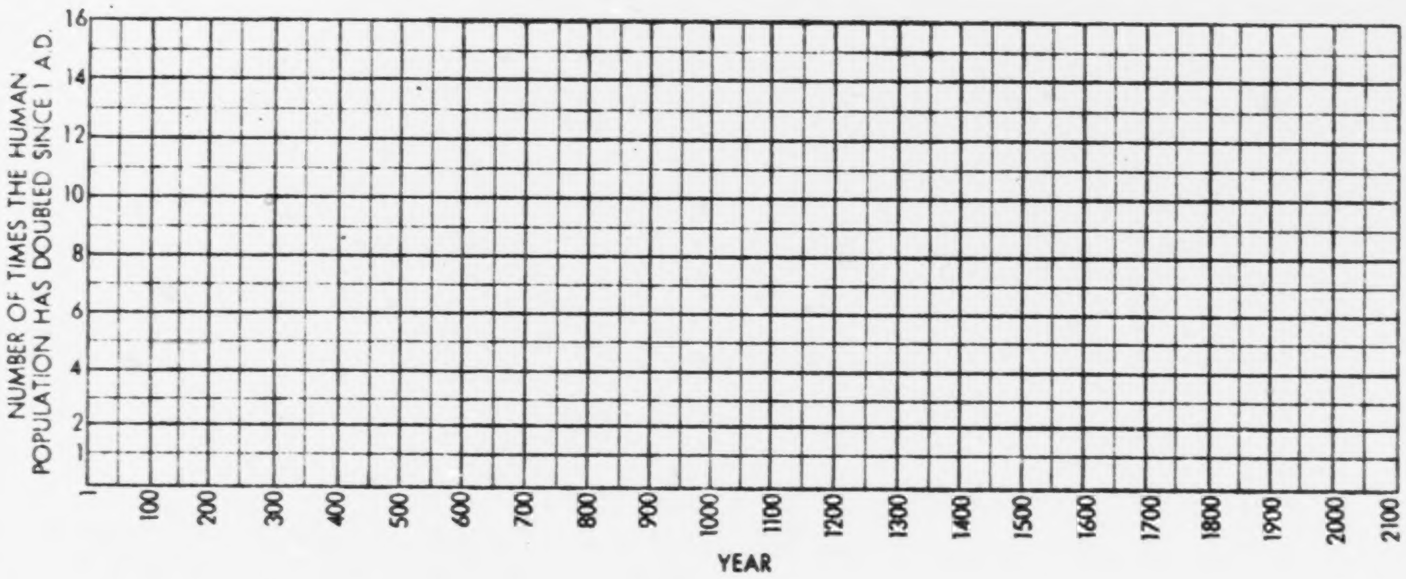
AUTHOR Biological Sciences Curriculum Study

PUBLISHER Holt, Rinehart and Winston, Inc.

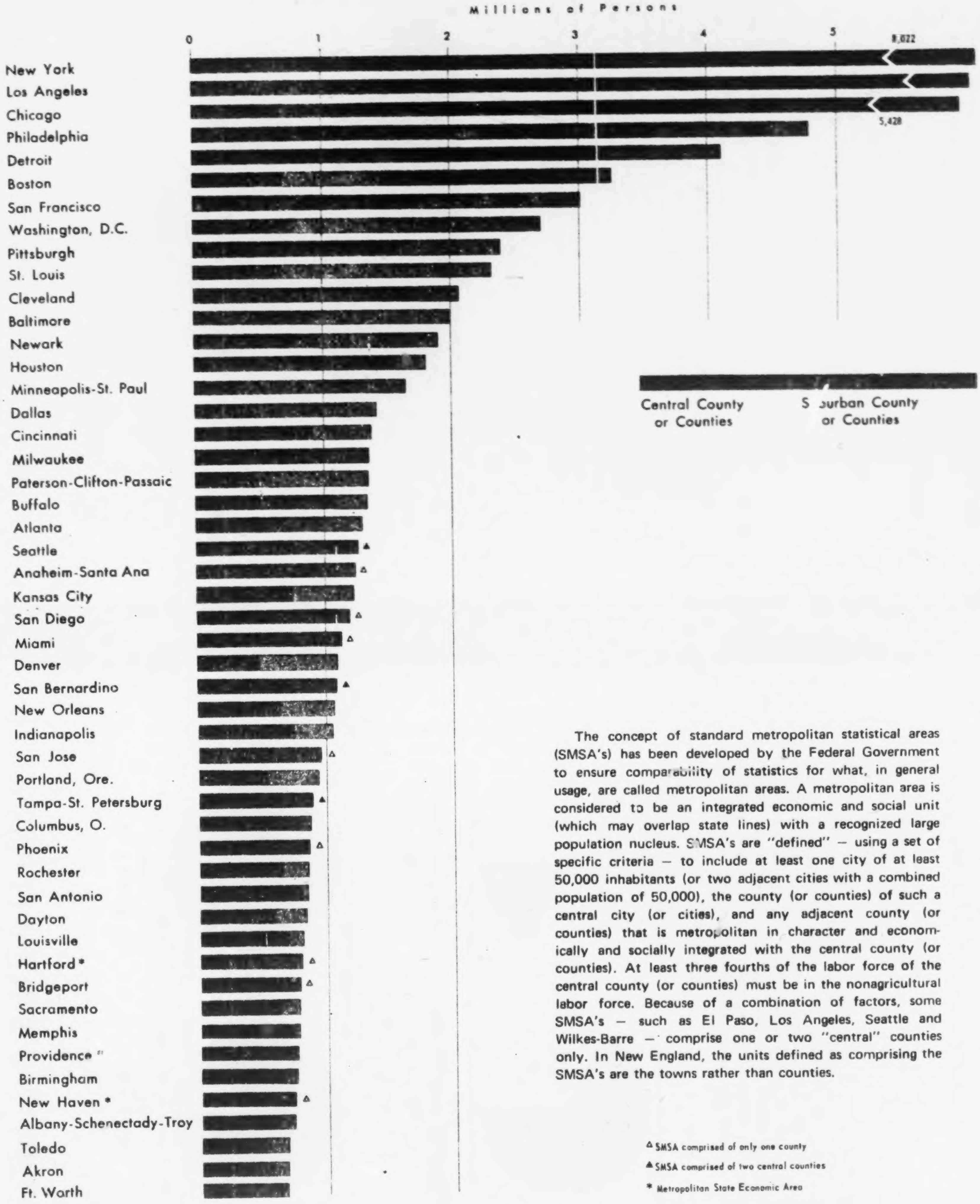
PAGE NO. 38

If you use the estimated figure of 12,000,000 people on the earth in the year 1 A.D., it is possible to see the number of times this population has doubled in any period of time. The human population had doubled by 1650. It had doubled over nine times by 1950. Here are some other figures:

Year (A.D.)	Number of times the population has doubled since 1 A.D.
1	1
1650	2
1750	3
1850	4.5
1950	9.2



Population of the 50 Largest Metropolitan Areas, 1967



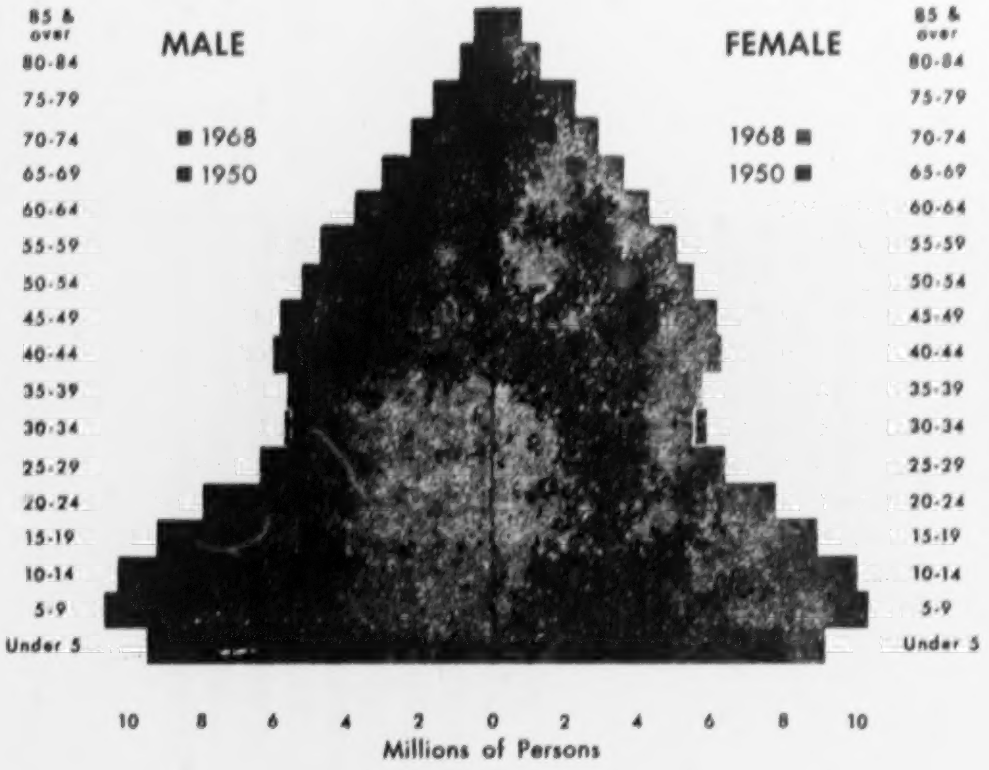
The concept of standard metropolitan statistical areas (SMSA's) has been developed by the Federal Government to ensure comparability of statistics for what, in general usage, are called metropolitan areas. A metropolitan area is considered to be an integrated economic and social unit (which may overlap state lines) with a recognized large population nucleus. SMSA's are "defined" — using a set of specific criteria — to include at least one city of at least 50,000 inhabitants (or two adjacent cities with a combined population of 50,000), the county (or counties) of such a central city (or cities), and any adjacent county (or counties) that is metropolitan in character and economically and socially integrated with the central county (or counties). At least three fourths of the labor force of the central county (or counties) must be in the nonagricultural labor force. Because of a combination of factors, some SMSA's — such as El Paso, Los Angeles, Seattle and Wilkes-Barre — comprise one or two "central" counties only. In New England, the units defined as comprising the SMSA's are the towns rather than counties.

△ SMSA comprised of only one county

▲ SMSA comprised of two central counties

* Metropolitan State Economic Area

Age Distribution of the American People



Shifts in the distribution of population by age in recent years have been perhaps even sharper than those affecting spatial distribution. The Depression-diminished crop of babies of the Thirities was followed by the flood of postwar children, and that is now followed by the current downswing in births. As those cohorts advance up the age ladder, the size of the population at each age level contracts or expands accordingly. Thus, between 1960 and 1968 the population aged 30-34 dropped by almost 1 million, the 20-24 bracket jumped by more than 4½ million, and the under 5-year roll declined 1.8 million. Meantime, life prolonging advances in medical science helped to boost the number of persons 65 and over by 2½ million.

Sources: Bureau of the Census;
Department of Commerce

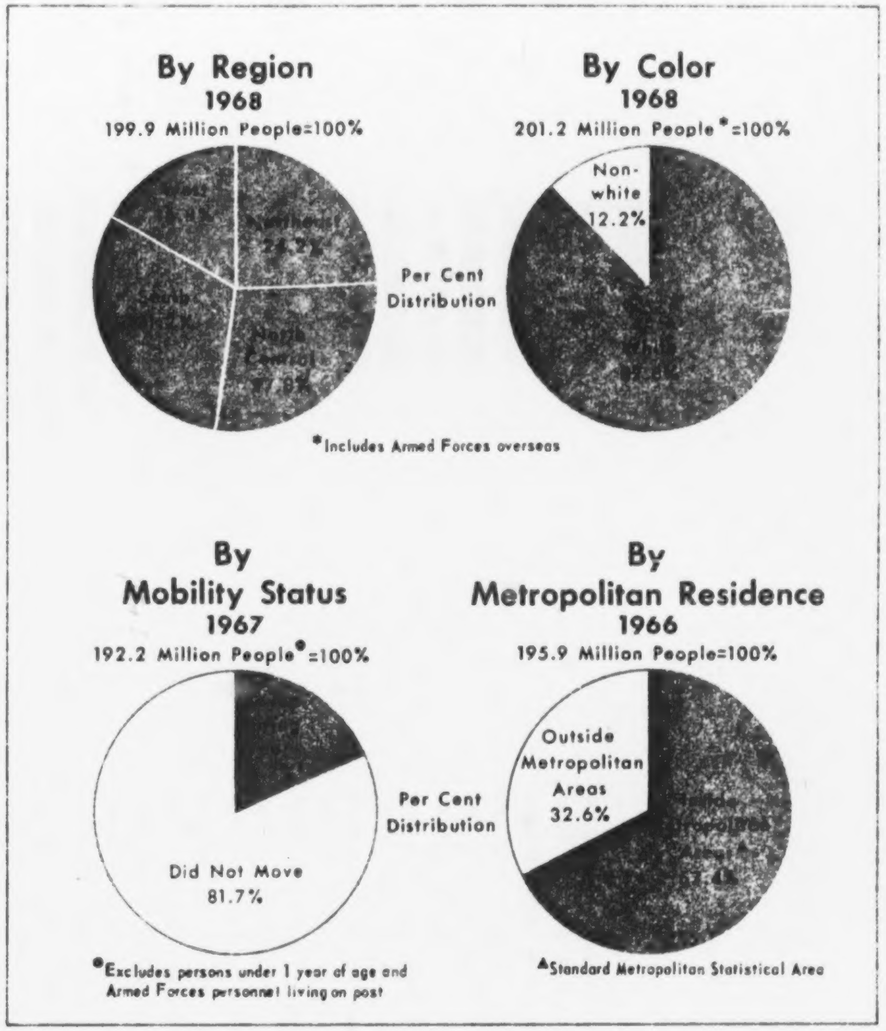
* * *

Quantities of this chart are available to Associates as follows:
10-24 copies, 8¢ each—25-99 copies, 6¢ each—100 or more, 5¢ each
Prices for larger quantities on request.

ROAD MAPS OF INDUSTRY
J. Frank Gaston, Editor; Bernard A. Gelb; Rosanne Reilly, Chief Chartist
Published twice monthly by
NATIONAL INDUSTRIAL CONFERENCE BOARD
615 Dorchester Boulevard West, Montreal 2, Canada ● 845 Third Avenue, New York, N. Y. 10022 ● 120 Oakbrook Mall, Oak Brook, Ill. 60523

ROAD MAPS OF INDUSTRY FROM THE CONFERENCE BOARD

Profile of the U. S. Population



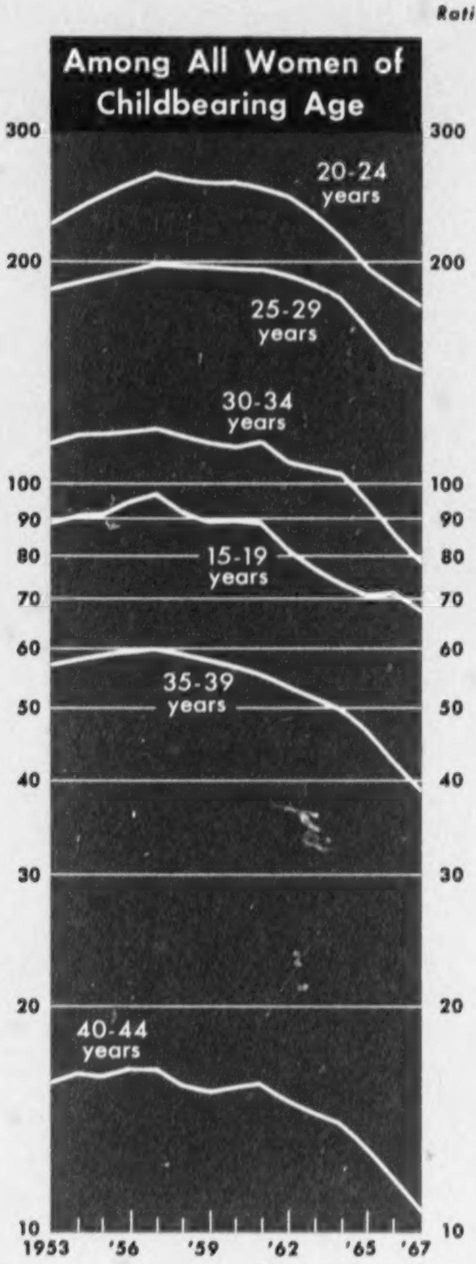
At the same time that it is becoming less concentrated by region, the U.S. population continues to increase its concentration in cities and their suburbs. In 1966, 67.4% of the people in the U.S. lived in one of the more than 200 standard metropolitan statistical areas, compared with 62.1% in 1950. Within the metropolitan-area-population category, however, there has been a continuing trend toward "decentralization" in two ways: the largest urban areas are accounting for a diminishing portion of U.S. metropolitan area population; and metropolitan areas in the West and South, for an increasing portion of U.S. metropolitan area population.

Although the movement of people westward has slowed a little during the Sixties, the proportion of the total U.S. population living in the 13 westernmost states still increased from 15.6% in 1960 to 16.8% in 1968.

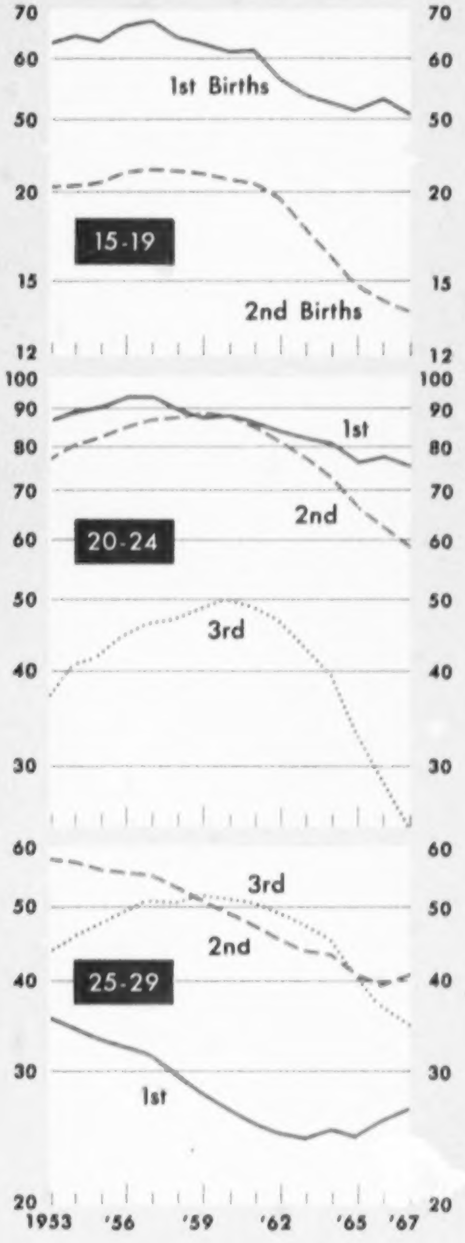
NATIONAL INDUSTRIAL CONFERENCE BOARD, Inc.

No. 1612 February 15, 1969

A Look at Birth Rates*...



Birth Order Rates Among Young Women



*Live births per 1,000 women in specified age group

* * *

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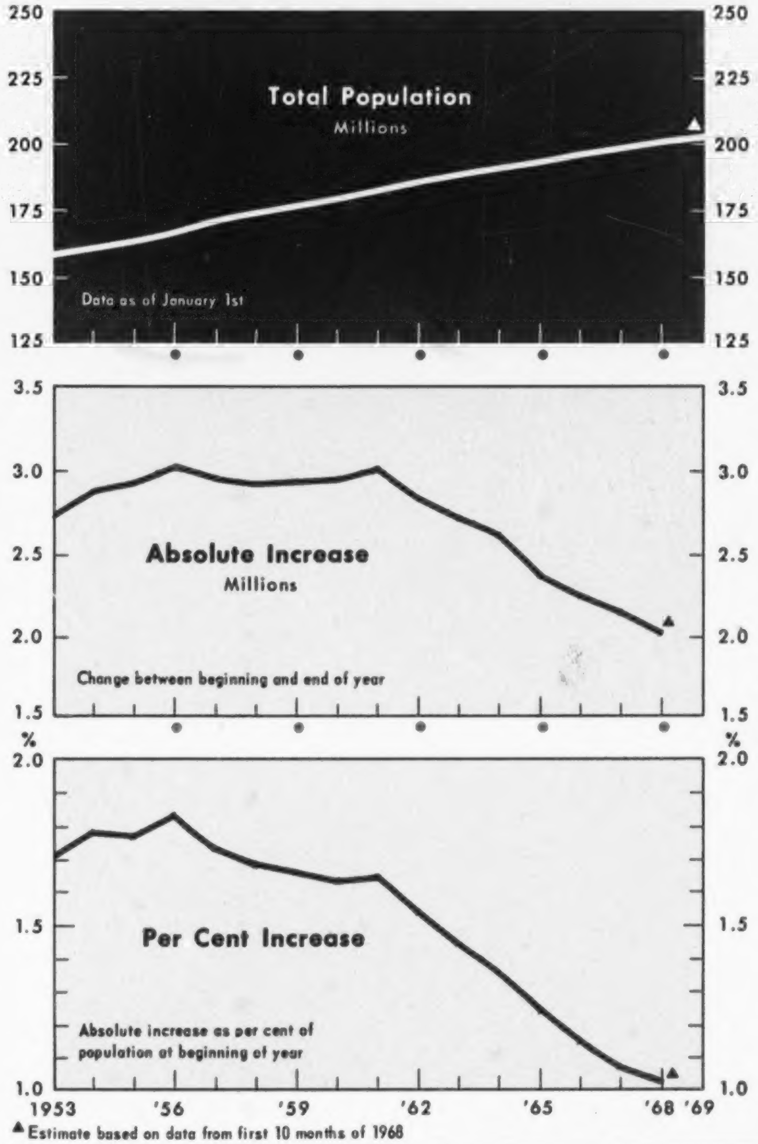
Trends in Population Change

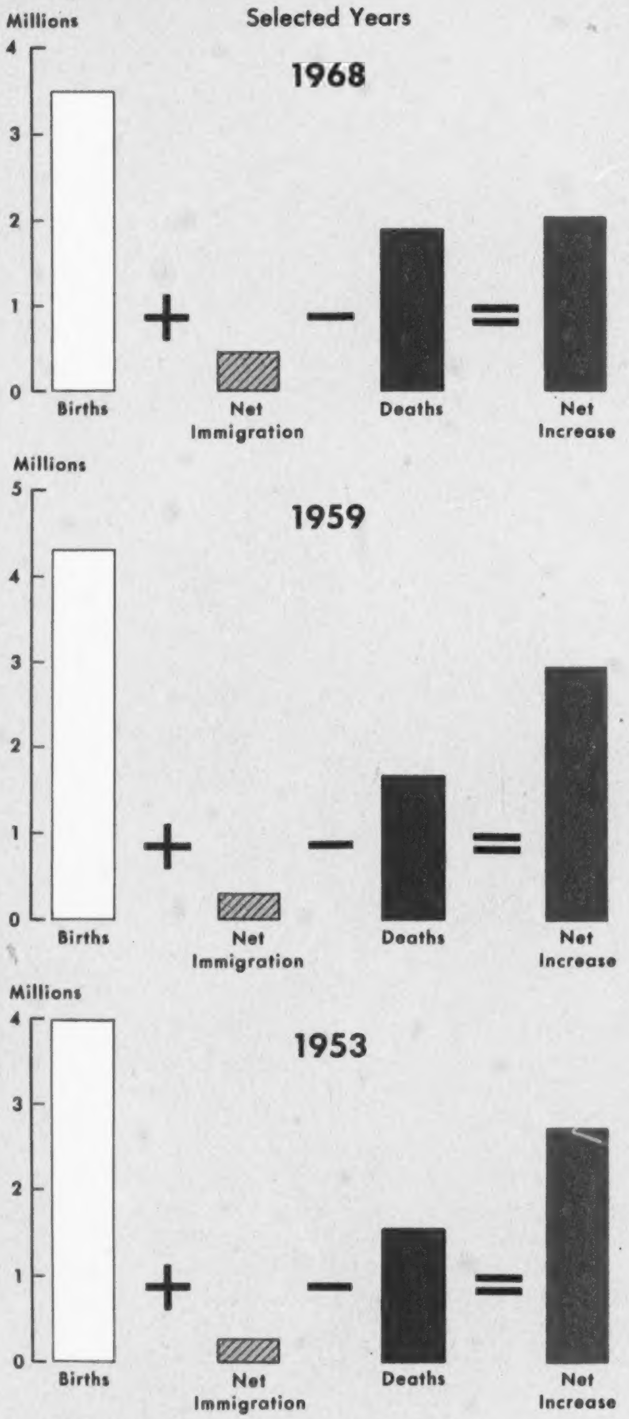


▲Estimate based on data from first 10 months of 1968

In contrast to the so-called "population explosion" in most of the rest of the world, population growth in the U.S. during the Sixties has been decelerating. Every year of the last seven has seen the number of people in the U.S. increase less (in absolute and percentage terms) than the year before; in 1968, the increase was probably less than 2.1 million, or just over 1%; in 1961, it rose by more than 3 million persons, or 1.65%. Whereas in the late Forties and most of the Fifties projections of the population by the Bureau of the Census consistently underestimated future growth that was to occur; the Census Bureau has twice revised its projections *downward* since 1966. Moreover, the population on July 1, 1968, stood between the two *lowest* of the Bureau's latest set (published in 1967) of four projection "series."

No. 1611 February 1, 1969

Components of Population Change



In the last seven years, trends in the components of population change have either become considerably less favorable for population increase or have shifted to neutral. Births have dropped markedly from their record of 4.2-4.3 million a year in 1956-61 to an estimated 3.5 million in 1968. Deaths have increased faster during the Sixties than they did in prior postwar years; since the mid-Fifties, the death rate has leveled off (following an extended decline). After a rise from low wartime levels, net immigration has nearly stabilized.

The decline in births has, however, been by far most important in limiting population growth; the drop in births reflects a much steeper fall in the birth rate.

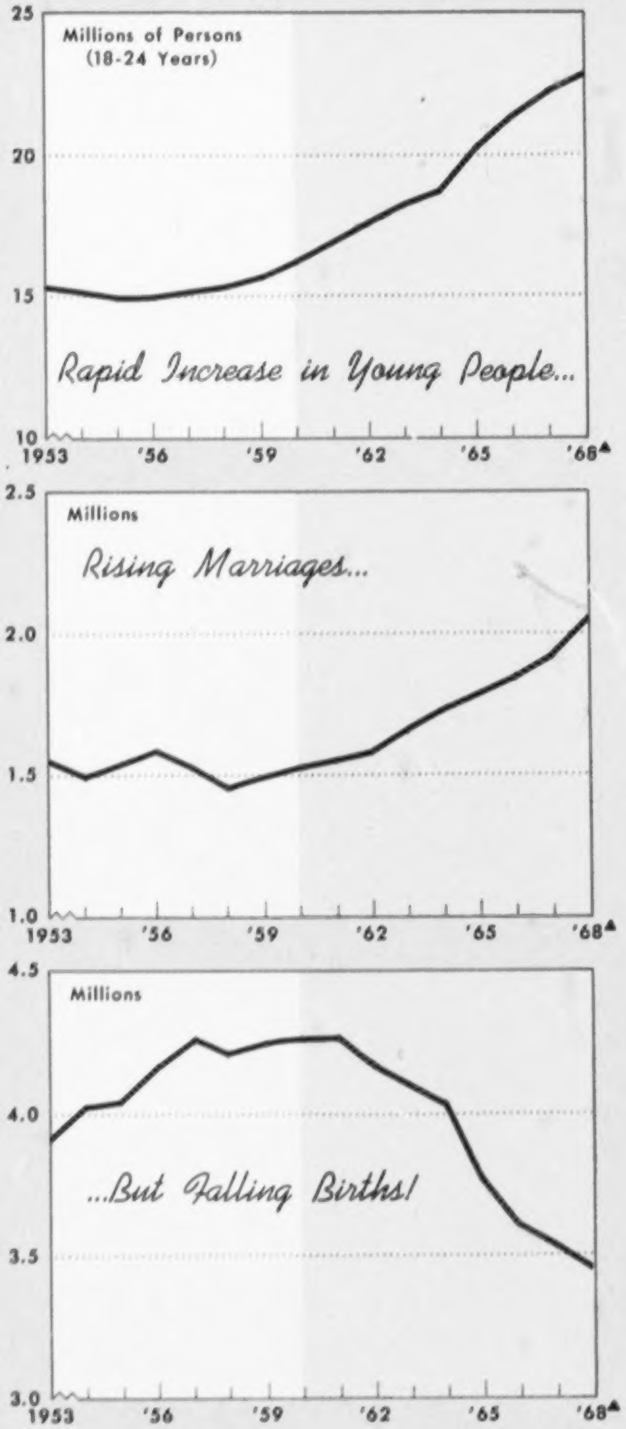
In puzzling contrast to the seven-year decline in births are the rises in the number of marriages and in the number of women in their prime childbearing years (20-29) – estimated at 32% and 28%, respectively. Marriages in 1968, at more than 2 million, were exceeded only in the immediate postwar year of 1946. In the early Sixties, births fell because increasingly early marriage and childbearing in the first dozen postwar years had pushed up birth rates; and part of the rise probably "borrowed" births from the future.

A Paradox of the Sixties

A significant part of the decline in the birth rate in the Sixties, however, has been accounted for by women in the two youngest childbearing age groups – women who generally were not old enough to have contributed significantly to the baby boom of the Fifties. Births per 1,000 women in the 15-19 and 20-24 age brackets fell by about 30% between 1959 and 1967. Because birth rates – especially births of second and third children – among the younger age groups are falling rapidly even though marriages are rising, it is generally agreed that much of the continued downtrend in fertility is attributable to postponement of childbearing by young couples. That these postponements indicate decisions to have fewer children is not yet verifiable and is still widely debated.

As regards birth control pills, the U.S. Public Health Service believes that, while the pill has contributed to the decline in fertility, a substantial reduction would have taken place anyhow. It notes that fertility is much higher now than in the Thirties, when available methods of birth control were presumably less convenient.

Sources: Bureau of the Census
Public Health Service



▲Estimate based on first 10 months' data

New York Herald Tribune

FAO: BIRTHS CANCEL FOOD OUTPUT GAINS

By Darius S. Jhabvala
Of The Herald Tribune Staff

UNITED NATIONS.

World food output made impressive gains during the past decade, but production increases in the main were wiped out by rapid population growth, the UN Food and Agricultural Organization said in a report published yesterday.

The report warned that world population is expected to grow at an even faster rate and prospects for any lasting improvement in agriculture "do not appear very bright."

It said a four-fold increase in production will be needed in the developing countries during the rest of this century just to keep pace with present standards.

The report was distributed three days after Pope Paul VI exhorted the General Assembly to strive "to multiply bread so that it suffices for the people of mankind and not rather favor artificial control of birth, which would be irrational."

FAO Director-General B. R. Sen said in the report that "technical means are available" to provide more food.

But, he warned the task cannot be accomplished "unless the leaders of nations are alive to the issues at stake and are prepared to devote a large share of the world's resources to meet the looming crisis."

He said the remaining years in this century "will be the most critical in human history." UN experts expect the world population of 3.3 billion almost to double by the end of the century.

Mr. Sen cautioned that "the third post-war decade is one when the Malthusian correctives (war, pestilence, famine) will inexorably come into play unless organized wil land dedicated endeavor, which we have been trying to build through various efforts, can find effective expression."

The report notes that the food-population situation has not only brought great urgency to the task of expanding production of food, "but has also begun to cause widespread rethinking of the attitude to population control."

Friday, October 8, 1965

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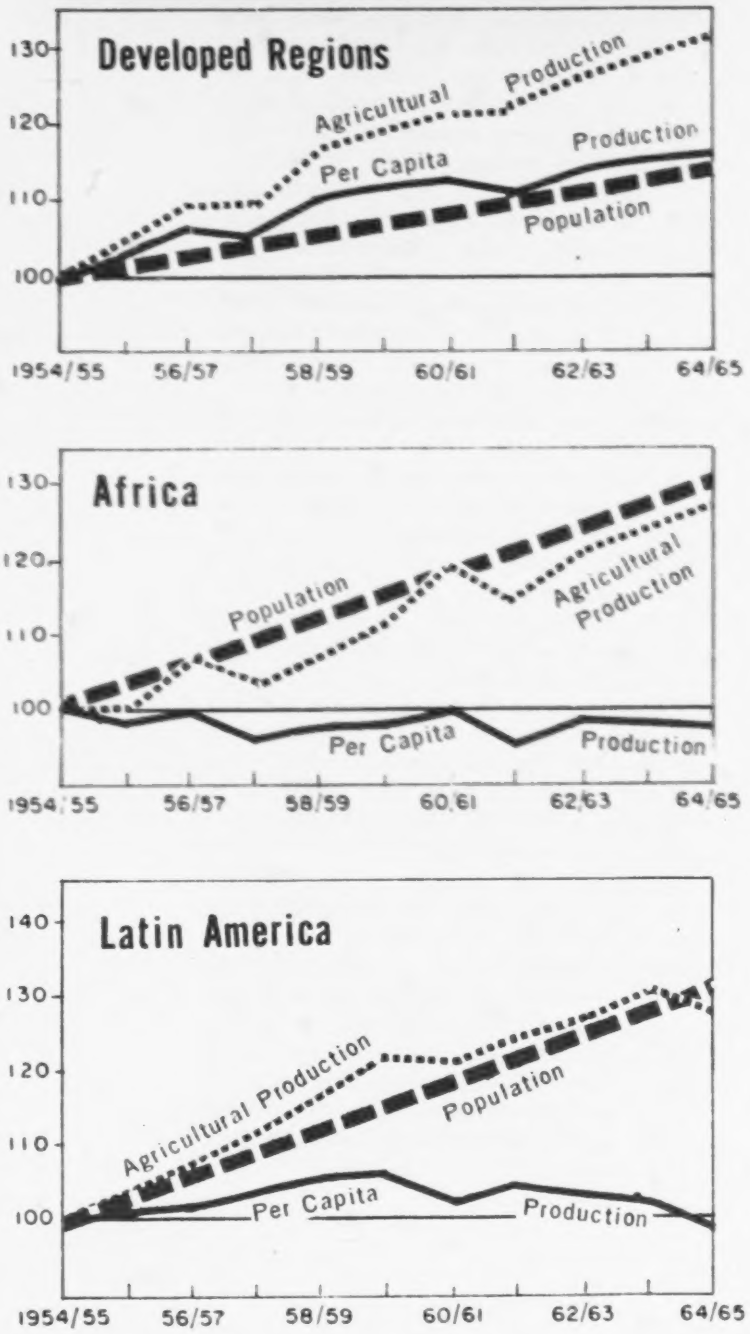
Agricultural Production and Population Growth



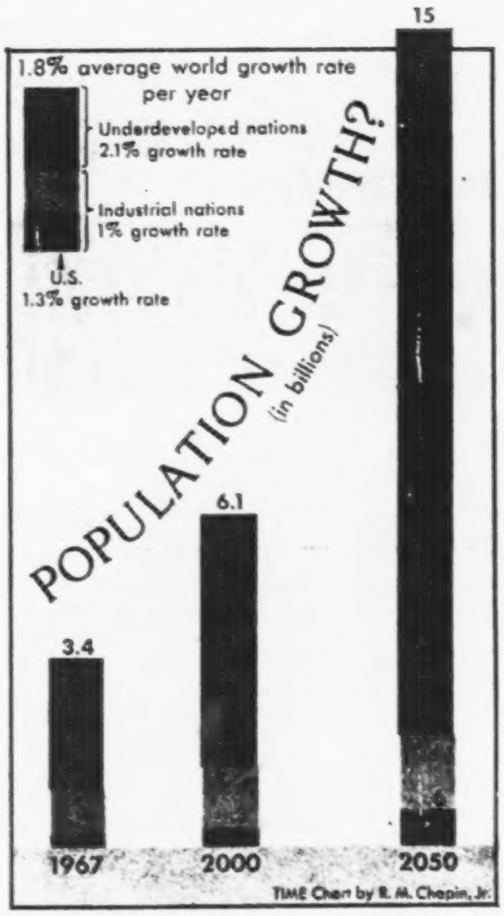
BIRTH CONTROL

For Zero Growth

This is the week when the 200 millionth U.S. citizen will be born; demographers fix the time and day at 11 a.m., Nov. 20. For the past several weeks, population planners have been leading up to the statistical moment with major birth-control news. In London, the International Planned Parenthood Federation announced last week that its 1968 budget would be $6,500,000, double that of 1967 and six times the amount it spent in 1965. Almost simultaneously, the Manhattan-based Population Council reported that family-planning efforts in Taiwan and South Korea had met with marked success, mainly through increased use of intra-uterine devices like the Lippes loop.

Are such advances sufficient to win the overall battle? No, says Professor Kingsley Davis, director of international-population and urban research at the University of California. Davis, in the Nov. 10th issue of *Science*, writes that the family-planning programs as presently conceived and executed cannot prevent the world from rapidly populating itself to doomsday.

Government Regulation. Statistical projections tend to bear Davis out. Even in the U.S., representative of literate industrial nations where birth control has become a byword, the predicted average annual population-growth rate is averaging 1.3%. Present projections put the U.S. population at 308 million by the year 2000, 374 million by 2015. World population now stands at 3.4 billion. At its present annual growth rate —about 1.8%—it will nearly double by A.D. 2000. By 2050 it will be 15 billion. Even if world population growth were brought into line with the present U.S. rate, it would still double by the year 2030.



TIME Chart by R. M. Chapin, Jr.

The answer, suggests Davis, is a natural population growth rate of zero (births equal to deaths), "for any growth rate, if continued, will eventually use up the earth." Such a drastic reduction in births might require absolute government regulation of the size of families —a concept that most nations have found impossible to accept. In a more Orwellian guise, writes Davis, such control might include pressure through limits on availability of housing, manipulation of inflation to force mothers to work, increased city congestion by the deliberate neglect of transit systems, and increased personal insecurity through rigged unemployment.

Overrun World. Davis does not think such appalling correctives need ever become necessary. Instead, he feels, futurists should accept the fact that persuasion, not family planning, is the answer to population growth. He suggests economic persuaders to encourage the postponement of marriage and the limitation of births within marriage. How? Among other methods, by charging substantial fees for marriage licenses; levying a "child tax"; taxing single persons less than married ones; eliminating tax exemptions for children; legalizing abortion and sterilization.

As extreme as Davis's suggestions are, he sees them as the best alternative to a world overrun by people.

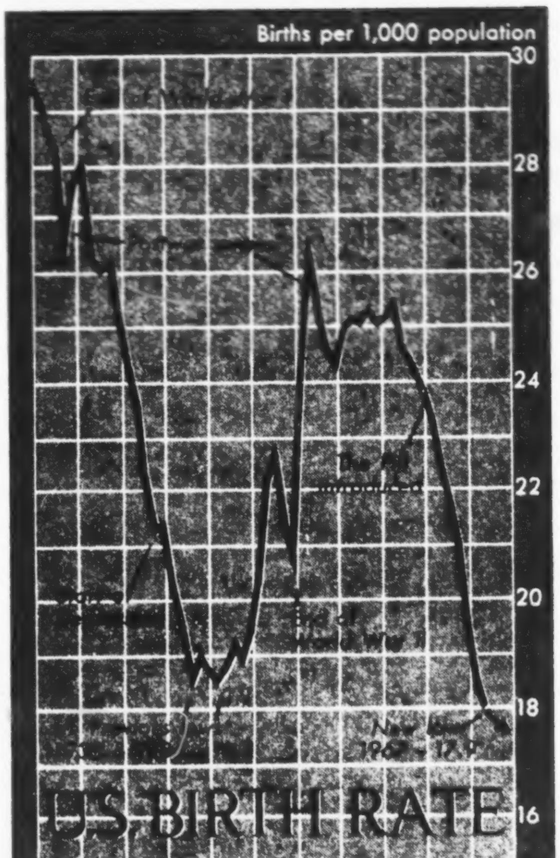
TIME, NOVEMBER 24, 1967

POPULATION

The Shrinking Family

The U.S. birth rate, falling steadily for the past decade, reached an alltime low last year, and is projected to drop even further in the years ahead. The 1967 rate, announced by Washington's National Center for Health Statistics, is 17.9 births for every 1,000 Americans, a figure below the previous record low of 18.4 set in the Depression years of 1933 and 1936.

The ups and downs of the U.S. birth rate (*see chart*) have experts pondering the mysteries of cause and effect. After both World Wars, there was a predictable surge after servicemen returned from overseas. But how to account for the drop during the prosperous 1920s and the affluent late '50s and '60s? The lowering birth rate has nothing to do with fertility, says Natality Statistics Chief Arthur A. Campbell; in fact, women are proving more fertile than the mothers of 30 years ago (88 babies for each 1,000 women of childbearing age *v.* 76 a generation ago). Nor did he hold the Pill solely responsible; the drop in births during the '20s, before today's sophisticated contraceptives were available, was equally steep.



TIME Chart by V. Puglisi

3/8/68 TIME

What seems to be determinant is changing fashions in family planning. After World War I, the ideal family became set at two children ("a boy for you, a girl for me"). During the Depression, hard economic realities held down the birth rate. After World War II, the vogue for large families, with three, four or more children, peaked in 1947 and continued for a full decade.

Today's pattern, according to Campbell, is for women to have children earlier and settle for fewer of them (average U.S. family is now 2.7 children). Says Robert C. Cook, president of Washington's Population Reference Bureau: "There is a growing realization on the part of younger couples in America that rearing children in this complicated and expensive world presents big problems." Among those cited by Cook: "Rising costs of living, increasing competition for education, especially at the college level."

The material on pages 103-116 may be found

TITLE High School Biology, Laboratory Manual

AUTHOR Biological Sciences Curriculum Study

PUBLISHER Rand, McNally and Company

PAGE NO. 26-39

Review Questions

POPULATION STRUCTURE AND DYNAMICS

1. Why is the study of natural populations so difficult?

2. Of all organisms man has the greatest ability to influence his environment.
    a. In what ways do other organisms influence environments?
    b. Has man's influence been more negative than positive? Explain.

3. What causes populations to change in size?

4. In what ways would an increase in an organism's life span effect its population?

5. Are the Malthusian factors (war, pestilence and starvation) any threat to our expanding populations today? Could they be in the future? If yes, when?

6. Why do northern populations characteristically show regular and violent oscillations between abundance and scarcity?

7. Do any other organisms, other than man, undergo population explosions? Are the limiting and balancing factors the same for human populations as other populations?

8. What factors are involved in the evolution of Homo sapien populations?

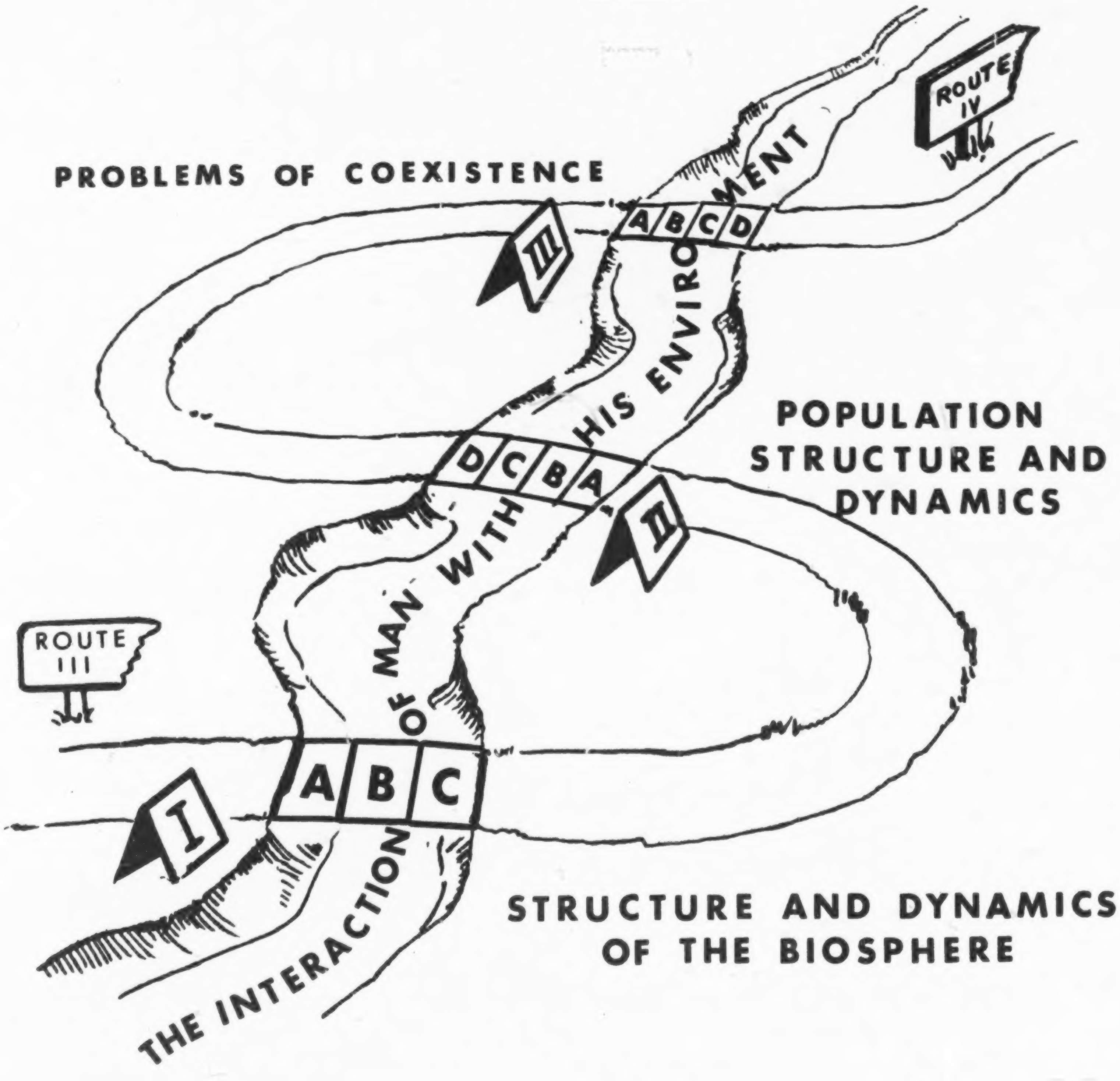
9. Is it a "good thing" for the human population to continue to expand at its present rate indefinitely? If not, how can population explosions be controlled without serious restriction or loss of individual liberties and responsibilities?

10. If the human population is allowed to expand without restrictions, will it mean the extinction of many other species now present on earth?

11. What are the effects of crowding upon human behavior?

12. What steps are necessary to ensure adequate nutrition for all members of the human race?

SCIENCE IIIB


PROBLEMS OF COEXISTENCE
ROUTE IV
A B C D
III
THE INTERACTION OF MAN WITH HIS ENVIROMENT
POPULATION STRUCTURE AND DYNAMICS
D C B A
II
ROUTE III
A B C
I
STRUCTURE AND DYNAMICS OF THE BIOSPHERE

A. PROBLEMS OF COEXISTENCE WITH THE PHYSICAL ENVIRONMENT

B. PROBLEMS OF COEXISTENCE WITH OTHER ORGANISMS

C. PROBLEMS OF COEXISTENCE WITHIN SOCIETY

D. SCIENCE AND THE EVOLVING SOCIETY

Problems of Coexistence with the Physical Environment

THE UTILIZATION OF NATURAL RESOURCES

Air

Water

Soils

Minerals

THE UTILIZATION OF NATURAL RESOURCES

"Endangering the Balance of Nature"

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Adapted From: "Protecting The Environment", Current/May, 1968

In recent years, we have heard much discussion of distinct and nearly independent cultures within our society that fail to communicate with each other - natural scientists and social scientists, for example. The particular failure of communication I am concerned with here is that between ecologists on the one hand and, on the other, those who consider that continuous growth is desirable - growth of population, industry, trade and agriculture. Put another way, it is the dichotomy between ..... those who insist that man should try to know the consequences of his actions before he takes them versus those who want to get on with the building of dams and canals, the straightening of river channels, the firing of nuclear explosives and the industrialization of backward countries.

The message that the ecologists . . . seek to impart could hardly be more urgent or important. It is that man, in the process of seeking a "better way of life", is destroying the natural environment that is essential to any kind of human life at all; that, during his time on earth, man has made giant strides in the direction of ruining the arable land upon which his food supply depends, fouling the air he must breathe and the water he must drink and upsetting the delicate chemical and climatic balances upon which his very existence depends. And there is all too little indication that man has any intention of mending his ways.

The aspect of this threat to human life that has received the least public attention, but which is, I believe, the most serious is the manner in which we are altering the biological, geological and chemical cycles upon which life depends.

When the world was young, it did not have the gaseous atmosphere that now surrounds our planet. The water that fills the oceans and atmosphere, were contained in the rocks formed in the earth's creation. They escaped by various degassing processes, the most dramatic of which was volcanic action.

The amount of oxygen in the atmosphere was negligible before the origin of living organisms that could carry on photosynthesis of the type characterizing green plants, which during daylight hours take in carbon dioxide and give off oxygen. At first, there was virtually no accumulation of oxygen in the atmosphere . . . But very gradually, some dead organisms began to pass out of circulation by being deposited in sedimentary rocks where some of them became the raw material for the creation of coal and oil. The oxygen that these well-buried organism would have used up, had they remained on the surface and been subject to decomposition, was allowed to remain in the atmosphere. And eventually, perhaps not until 400 million years ago, this unused oxygen brought the level of oxygen in the atmosphere to slightly over 20 percent.

This is the same percentage of oxygen in the atmosphere today. Apparently, the combination of green plants and oxygen-using organisms, inluding animals, became very efficient at taking oxygen from the atmosphere and returning it at equal rates. And this is true in spite of the fact that photosynthesis stops during the hours of darkness and practically stops during winter on land areas in high latitudes . . . We have been fortunate that atmospheric circulation patterns move the air about the globe in such a way that we have not had to be concerned that man would run out of oxygen to breathe at night or in winter. As we shall see, man is today pushing his luck.

Another chemical element essential to life is carbon. Plants use carbon dioxide to build their organic compounds, and animals combine the organic compounds with oxygen to obtain the energy for their activities. And all this is possible only because, millions of years ago, the deposition of organic matter in sedimentary rocks led to the creation of a reservoir of oxygen in the atmosphere.

The carbon-oxygen relationship is essential to photosynthesis and thus to the maintenance of all life. But should this relationship be altered, should the balance between the two be upset, life as we know it would be impossible. Man's action today is bringing this imbalance upon us.

The carbon dioxide in the atmosphere is created in large measure by combustion. Before the time of man, the combustion in the earth's forests was spontaneous. Early man set forest fires to drive game and burned timber for warmth; he went on to find other uses for combustion and to find new combustible materials. First it was coal for heat and power, then oil and natural gas. The exploitation of these so-called fossil fuels made it possible for more people to exist on earth simultaneously than has ever been possible before. It also brought about our present dilemma: The oceans are the world's great reservoir of carbon, taking carbon dioxide from the atmosphere and precipitating it as limestone; we are now adding carbon dioxide to the atmosphere more rapidly than the oceans can assimilate it.

Industrial facilities, automobiles and private homes are the big consumers of fossil fuels, but to appreciate the magnitude of the problem, consider very briefly a still minor source of atmospheric pollution, the airplane, which may have disproportionate importance because of the fact that much of the carbon dioxide and water vapor produced by the combustion in its engines are released at high altitudes, where they are only slowly removed from the atmosphere.

When you burn a ton of petroleum hydrocarbon, you obtain as by-products about one and a third tons of water and about twice this amount of carbon dioxide. A Boeing 707 in flight accomplishes this feat about every 10 minutes. I read in the papers that 10,000 airplanes per week land in New York City alone, not including military aircraft. If we assume very crudely that the 707 is typical of these airplanes, and that its average flight takes four hours, this amounts to an annual release into the atmosphere of about 36 million tons of carbon dioxide. And not all flights have a terminus in New York.

Thus the amount of carbon dioxide put into the atmosphere is rising at an ever-rising rate. At the same time, we are removing vast tracts of land from the cycle of photosynthetic production - in this country alone, nearly a million acres of green plants are paved under each year. The loss of these plants is drastically reducing the rate at which oxygen enters the atmosphere. And we do not even know to what extent we are inhibiting photysynthesis through pollution of fresh-water and marine environments.

The carbon-oxygen balance is tipping. When, and if, we reach the point at which the rate of combustion exceeds the rate of photosynthesis, we shall start running out of oxygen . . .

The increase in the proportion of carbon dioxide in the atmosphere will have other effects. Carbon dioxide and water vapor are more transparent to shortwave solar radiation than to the longwave heat radiation from the earth to space. Thus the increased proportion of these substances in the atmosphere tends to bring about a rise in the earth's surface temperature, the so-called greenhouse effect, altering climates in ways that are still highly controversial in the scientific community but that everyone agrees are undesirable.

One school holds that the increase in temperature will melt the icecaps of Greenland and the Antarctic, raising the sea level by as much as 300 feet and thereby obliterating most of the major cities of the world. Another school believes that higher temperatures will bring about an increase in evaporation and with it a sharp rise in precipitation; the additional snow falling upon the icecaps will start the glaciers moving again, and another Ice Age will be upon us.

And these represent only the less-known effects of combustion of the world. They do not include the direct hazards from air pollution - on man's lungs, for example, or on vegetation near some kinds of industrial plants. Nor do they include the possibility, suggested by some scientists, that we will put enough smoke particles into the air to block solar radiation, causing a dangerous decrease in the earth's temperature. Just to indicate the complexity and uncertainty of what we are doing to the earth's climates, I should mention that the smoke-caused decrease in temperatures would most likely be offset by the carbon dioxide-caused greenhouse effect.

In any case, if we don't destroy ourselves first, we are eventually going to run out of fossil fuels - a prospect surely not many generations away. Then, presumably, we shall turn to atomic energy . . . And then we will face a different breed of environmental pollution.

A prime example of what irresponsible use of atomic power could bring about is provided by the proposal to use nuclear explosives to dig a sea-level canal across Central America. The argument in its favor is that it is evidently the most economical way to accomplish the task. Yet consider the effects upon our environment. If 170 megatons of nuclear charges will do the job, as has been estimated by the Corps of Engineers which apparently wants to do it, and if the fission explosions take place in average materials of the earth's crust, encugh ^{137}Cesium would be produced to give every person on earth a radioactive dosage 26.5 times the permissible exposure level . . .

121 The sea-level canal also poses other dangers, whether or not atomic explosives are used. In that latitude the Pacific Ocean stands higher than the Atlantic by a disputed amount I believe to average 6 feet. The tides are out of phase on the two sides of the Isthmus of Panama, so the maximum difference in level can be as great as 18 feet; and the Pacific has much colder water than the Atlantic. Just what would happen to climates or to sea food industries in the Caribbean if a new canal moved a mass of cold Pacific water in there is uncertain; but I have heard suggestions that it might creat a new hurricane center, or even bring about diversion of the Gulf Stream with a drastic effect on the climates of all regions bordering the North Atlantic . . .

So much of the danger to man is summed up in that simple phrase, "We don't know". For example, consider the nitrogen cycle, which provides that element all organisms require for the building of proteins. Nitrogen is released into the atmosphere, along with ammonia, as a gas when plants and animals decay; live plants use both elements to build their proteins, but they cannot use nitrogen in gaseous form - that task is accomplished by certain bacteria and primitive algae in the soil and the roots of some plants. Animals build their proteins from the consituents of plant proteins. As in the case of oxygen, the rates of use and return of nitrogen have reached a balance so that the percentage of nitrogen in the atmosphere remains constant.

If any one of these numerous steps in the nitrogen cycle were to be disrupted, disaster would ensue for life on earth. Depending upon which step broke down, the nitrogen in the atmosphere might disappear, it might be replaced by poisonous ammonia or it might remain unused in the atmosphere because the plants could not absorb it in gaseous form.

Are any of these possibilities at hand? Has man's interference with natural processes begun to have a serious effect on the nitrogen cycle? The point is, we don't know - and we should, before we do too much more interfering. We are dumping vast quantities of pollutants into the oceans. According to one estimate by the United States Food and Drug Adminsistration, these include a half-million substances; many are of recent origin, including biologically active materials such as pesticides, radioisotopes and detergents to which the ocean's living forms have never before had to try to adapt. No more than a minute fraction of these substances or combination of them have been tested for toxicity to life - to the diatoms, the microscopic marine plants that produce most of the earth's oxygen, or to the bacteria and microorganisms involved in the nitrogen cycle . . .

Problems of Coexistence with the Physical Environment

AIR

The Atmosphere as a Resource

The Growing Problem of Air Pollution

THE ATMOSPHERE AS A RESOURCE

Resource Material:

Required Reading:	The Atmosphere, Chapter 29, Modern Chemistry Science & Technology, July 1969
Recommended Reading:	Encyclopedia of Science and Technology, section on atmospheric gases "Is Our Atmosphere Seeping Away?", Science World, April 21, 1967 "Ionosphere - Mirror in Space", Senior Science, May 12, 1967

INTRODUCTION:

Life on planet Earth is possible because of the atmosphere of gases which surround the earth. The atmosphere is the resource from which plants and animals draw their supply of oxygen and carbon dioxide gases which are absolutely essential to their life process. Man can survive for months without food, for days without water, but for only a few minutes without oxygen.

As vital as our atmosphere is to life, man tends to take this resource more for granted than any other. This is probably because of the ease with which he is able to draw from it the substances which are essential to his survival. No person in good health considers that breathing is hard work. It is done effortlessly, unconsciously, and without concern about whether the atmosphere contains sufficient oxygen for his next breath, for his breathing next year or ten years from now. This is taken for granted.

The problems which we now experience in our use of the atmosphere as a resource are, in the final analysis, problems of pollution and contamination. Our problem is that we are dumping so much "garbage" into the atmosphere that these pollutants are beginning to get in our way. Much of our problem is associated with the idea that man regards the atmosphere as an unlimited space into which he can continue to dispose of his waste products forever and ever and at the same time expect the atmosphere to continue to supply the gases, generate the rainfall, and transmit the energy he requires.

The truth of the matter is that the atmosphere is far from being a limitless space. If one were to think of the earth as an object about the size of an apple, the layer of gases which make up the earth's atmosphere would have about the same relative thickness as the skin of the apple. It is this thin ocean of air that supplies man with the oxygen he breaths, shields him from the harmful radiation in outer space, provides him with a fresh supply of water, comforts him with breezes, serves as a medium for the transportation of matter and energy, and far from least, provides an esthetic background of variations in blue and white which does much to make the whole experience of life seem worth-while.

In this part of our study we will look more closely at the composition and some of the properties of this relatively thin layer of gases. Our purpose is to learn more about the mixture of gases we call the atmosphere and about the ways in which it is used by man. Hopefully, this portion of our study will give us an even greater appreciation for the importance of our air resource.

QUESTIONS FOR CONSIDERATION:

1. What is the chemical make up of the earth's atmosphere?

2. Is the composition of the earth's atmosphere changing?

   What implications does this have for life in general and man in particular?

3. How high does the atmosphere extend above the surface of the earth?

   What are the characteristics of the atmosphere at various levels?

4. What is the density of air?

   What factors affect the density of air?

5. How much pressure does the atmosphere exert upon the earth?

   How is this pressure measured?

6. In what ways is man dependent upon the atmosphere?

I. Characteristics of the Atmosphere

A. Chemical Composition of the Atmosphere

1. Percentage Composition of Dry Air at Sea Level

Name of Gas	% Composition by Volume	Density g/l	Boiling Pt. degree C^{o}	Remarks
Nitrogen	78.09			
Oxygen	20.95			
Argon	0.93			
Carbon Dioxide	3.0×10^{-2}			
Neon	1.8×10^{-3}			
Helium	5.2×10^{-4}			
Methane	1.5×10^{-4}			
Krypton	1.14×10^{-4}			
Nitrous Oxide	5.0×10^{-5}			
Hydrogen	5.0×10^{-5}			
Ozone	4.0×10^{-5}			
Carbon Monoxide	1.0×10^{-5}			
Xenon	8.6×10^{-6}			
Acetylene	2.0×10^{-6}			
Sulfur Dioxide	1.0×10^{-6}			
Hydrogen Chloride	1.0×10^{-6}			
Ammonia	5.0×10^{-7}			
Nitrogen Dioxide	1.0×10^{-7}			
Radon	6.0×10^{-18}			

2. Water Vapor Content of the Atmosphere

B. Structure of the Atmosphere

1. Pressue - Temperature gradients Within the Atmosphere

ALTITUDE (MILES)	TEMPERATURE (AVG. SEASONAL)	PRESSURE (lbs / ft^2)
0	+ 15 °C	2.12×10^{3}
6.86	- 56 °	4.73×10^{2}
12.4	- 56 °	1.16×10^{2}
15.6	- 56 °	3.2×10^{1}
19.0	- 47 °	
19.9	- 35 °	1.81×10^{1}
25	- 7 °	
28	+ 5 °	
29.2	+ 10 °	2.52
33	+ 8 °	1.22
37	- 13 °	
46.7	- 61 °	5.12×10^{-2}
50	- 65 °	
56	- 76 °	3.79×10^{-3}
68	- 13 °	
78	+ 50 °	3.03×10^{-5}
109	+ 540 °	1.29×10^{-6}
140	+ 1250 °	
187	+ 1265 °	3.02×10^{-8}

2. Divisions of the Atmosphere

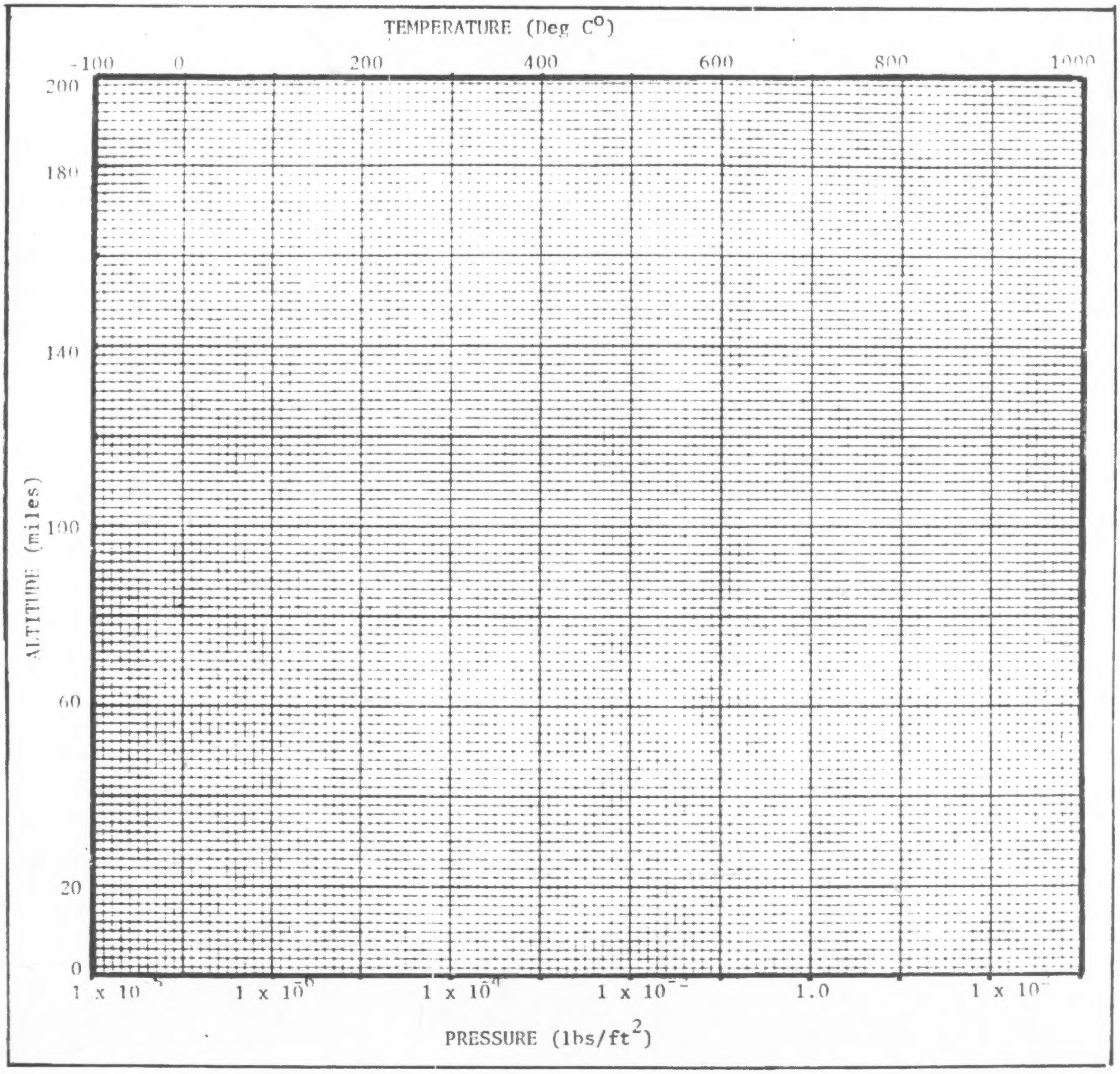
   a. Troposphere

Name ______________________

Science IIIB Hour ___

Date ______________________

PRESSURE - TEMPERATURE GRADIENTS WITHIN THE ATMOSPHERE



b. Stratosphere

c. Mesosphere

d. Ionosphere

e. Exosphere

C. Physical Properties

1. Density

a. Average Density of Dry Air

b. Factors which Affect the Density of Air

2. Pressue

a. Pressure of the Atmosphere at the Earth's Surface

b. Factors Affecting Atmospheric Pressure

c. Affect of Atmospheric Pressure on Boiling Point of Liquids

3. Water Vapor Concentration

a. Absolute Humidity

b. Dew Point

c. Relative Humidity

C. Physical Properties

1. Density

   a. Average Density of Dry Air

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3. Water Vapor Concentration

   a. Absolute Humidity

   b. Dew Point

   c. Relative Humidity

Laboratory Problem

Name ____________________
Science IIIB Hour ___
Date ____________________

THE DENSITY OF AIR

INTRODUCTION:

The density of air is so small compared to most other familiar examples of matter which we encounter in everyday experience that many persons have the impression that air does not weigh anything. This, of course, is not true! Air is "matter" and like all matter, it takes up space and has weight. In this laboratory problem you will attempt to determine the density of air, that is, the weight of a known volume of air:

$$D = \frac{W}{V}$$

Since the density of air is very small you must be very deliberate and precise in each technique of your experimental procedure. Your measures of weight must be accurate to two decimal places (0.01 g) and estimated to the third place. Values for volume should also be accurate to the hundredths and estimated to the thousandth's decimal place.

PROBLEM:

To measure the density of air in grams per cubic centimeters.

PROCEDURE:

In designing an experiment to accurately measure the weight and volume of a sample of air certain problems would have to be taken into account and experimental procedures designed to cope with them.

Identify the problems that you see as obstacles to the success of this approach and an experimental procedure which could be used to handle each problem.

PROBLEM	SUGGESTED APPROACH

Laboratory Problem

Name ______________________

Science IIIB Hour _____

Date ______________________

THE DENSITY OF AIR

PROBLEM:

To measure the density of air in grams per cubic centimeters.

EXPERIMENTAL DATA:

Weight of empty balloon ______________

Weight of balloon + air ______________

Volume of water displaced by air in the balloon ______________

INTERPRETATION OF RESULTS:

QUESTIONS:

1. Assuming no technical errors in measurement, is your experimental value for the density of air likely to be high or low? ____________ Explain.

2. On the basis of your value for the density of air calculate the weight of one liter of air.

   ____

3. If the density of air equals 1.3 oz. per cubic foot, calculate the weight of the air in a classroom 28 x 42 x 12 feet.

   ____

4. Identify two factors responsible for variations in the density of air.

Laboratory Investigation

THE AFFECT OF ATMOSPHERIC PRESSURE ON THE BOILING POINT OF LIQUIDS

INTRODUCTION:

The particles which make up gases and liquids have mobility. They possess sufficient kinetic energy to move about throughout the vessel that contains them. All the particles within a liquid, maintained at a uniform temperature, possess the same average kinetic energy. However, experience with our kinetic molecular model suggests that at any given moment the kinetic energy of individual particles varies from zero to some maximum value proportionate to the temperature of the liquid.

Particles having the highest kinetic energy are able to break through the surface of the liquid and escape into the surrounding air. The pressure exerted by those escaping particles is called "vapor pressure".

The pressure of the atmosphere upon the surface of a liquid has a "cover" effect which tends to prevent the escape of particles from the surface of the liquid. As the temperature of a liquid is raised, particles escape at a faster rate and subsequently the vapor pressure of the liquid is increased.

The temperature at which the vapor pressure of a liquid is equal to the atmospheric pressure is called the "boiling point". Any liquid may be made to boil at a wide range of temperatures simply by adjusting the atmospheric pressure on its surface.

Just as it is illogical to talk about the volume occupied by a gas without indicating its pressure and temperature, so to, it is illogical to talk about the boiling point of a liquid without specifying the pressure at which that particular boiling temperature is acheived.

Water boils at 100°C or 212°F only when the atmospheric pressure on its surface is equal to 760 mm. of mercury, that is, "one atmosphere".

In this investigation, we shall try to establish the relationship which exists between the boiling point of a liquid and the atmospheric pressure on its surface.

In particular we wish to determine the type of numerical relationship that exists between these two variables. This relationship can be illustrated graphically.

Laboratory Investigation

Name ______________
Science IIIB Hour ____
Date ______________

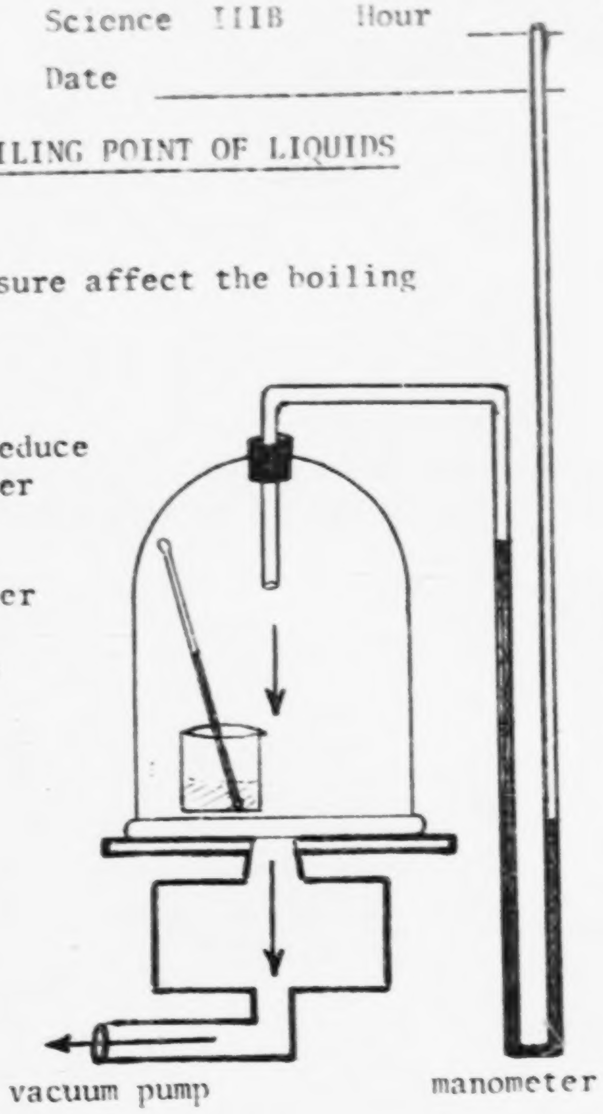
THE EFFECT OF ATMOSPHERIC PRESSURE ON THE BOILING POINT OF LIQUIDS

PURPOSE OF THE INVESTIGATION:

To determine how changes in atmospheric pressure affect the boiling point of water.

PROCEDURE:

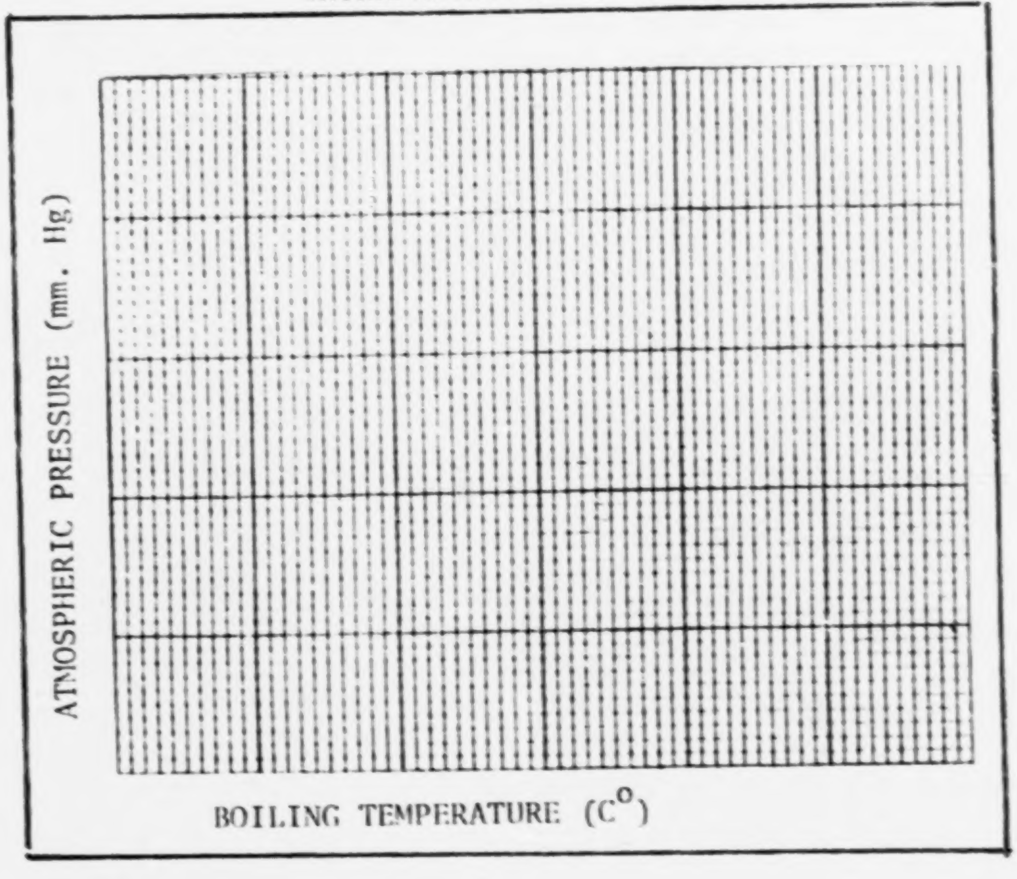
Place a beaker of water under a bell jar. Reduce the pressure inside of the jar until the water in the beaker starts to boil. Measure the water temperature and the pressure of the "atmosphere" within the bell jar. A manometer may be used to measure the pressure in mm. of mercury. Repeat this procedure six times using water, ranging in temperature from about 20°C to 90°C.



DATA:

Temp. of Boiling Water	Pressure of Atmos.

INTERPRETATION OF RESULTS



QUESTIONS:

1. How is the boiling point of a liquid numerically related to the atmospheric pressure on its surface?

2. Based on your experimental data, estimate the vapor pressure of water at zero degrees Centigrade.

3. What effect would an increase in atmospheric pressure have on the rate which gases dissolved in liquids could be diffused into membranes?

4. Can water have a vapor pressure in excess of 760 mm. of Mercury? Explain.

Laboratory Investigation

MOISTURE CONTENT OF THE AIR

INTRODUCTION:

Molecules of water vapor are always present in the air, even in dry dessert air.

These water vapor molecules move with great speed, just as the other molecules in the air mixture. The pressure exerted by these molecules of water vapor present in the air is called "VAPOR PRESSURE." The vapor pressure + the pressure exerted by the other gas molecules present in the air mixture = the total pressure exerted by the atmosphere.

There is a maximum number of water vapor molecules that a given volume of air can hold at any specific temperature. The "capacity" for air to hold moisture increases with temperature.

Air which contains the maximum amount of water vapor at a specific temperature is said to be SATURATED. The vapor pressure exerted by the water vapor molecules in saturated air at various temperatures have been measured and these "vapor pressures" are recorded in tables.

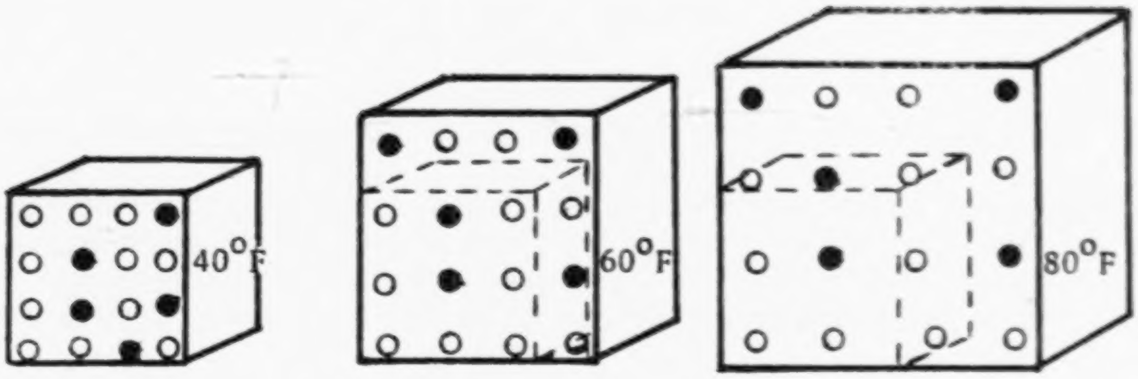
PRESSURE OF WATER VAPOR IN MILLIMETERS OF MERCURY

°C	mm	°C	mm	°C	mm	°C	mm
0.0	4.6	17.5	15.0	22.5	20.4	30.0	31.8
5.0	6.5	18.0	15.5	23.0	21.1	35.0	42.2
7.5	7.8	18.5	16.0	23.5	21.7	40.0	55.3
10.0	9.2	19.0	16.5	24.0	22.4	50.0	92.5
12.5	10.8	19.5	17.0	24.5	23.1	60.0	149.4
15.0	12.8	20.0	17.5	25.0	23.8	70.0	233.7
15.5	13.2	20.5	18.1	26.0	25.2	80.0	355.1
16.0	13.6	21.0	18.7	27.0	26.7	90.0	525.8
16.5	14.0	21.5	19.2	28.0	28.3	95.0	633.9
17.0	14.5	22.0	19.8	29.0	30.0	100.0	760.0

The percentage of water vapor present in the air is variable. At times it is saturated and we experience rain or precipitation in some other form, depending upon other weather conditions. Other times the vapor pressure is only a small percentage of the "maximum" and we say the HUMIDITY is low - or - the air is "dry."

The ratio of the amount of water vapor in the air at a given time (The Absolute Humidity) to the maximum amount that the air could hold (capacity) at the same temperature is called RELATIVE HUMIDITY.

$$\text{Relative Humidity} = \frac{\text{Absolute Humidity}}{\text{Capacity}}$$



v.p. = v.p. = v.p. =

If air is cooled, its volume decreases and the amount of water vapor present per cubic foot increases. If the air is cooled enough the air will become saturated.

The temperature to which the air must be cooled in order to saturate the air is called the dew point. When air is cooled to the dew point water vapor molecules begin to condense on cold surfaces.

We shall use this principle as a basis for measuring the relative humidity of the air.

Our present problem is to determine the vapor pressure due to the water vapor molecules present in the air now and compare this pressure to what it would be if the air was at room temperature and was saturated with water vapor.

The vapor pressure for saturated air at room temperature may be determined directly from the table.

The actual vapor pressure, due to the water vapor molecules actually present in the air, may be determined by measuring the temperature to which the air must be cooled before it becomes saturated. The vapor pressure at this dew point temperature may be taken from the table.

The ratio of the vapor pressure of the air, the vapor pressure at the dew point, to the vapor pressure of the air if it were saturated at room temperature describes the degree to which the air is saturated at room temperature. This is called the relative humidity.

$$\text{relative humidity} = \frac{\text{absolute humidity}}{\text{capacity}} = \frac{\text{VP at dew point temp.}}{\text{VP at room temperature}}$$

Laboratory Investigation

Name ______________________

Science IIIB Hour ____

Date ______________________

MOISTURE CONTENT OF AIR

PROBLEM:

To determine the relative humidity of the air in the classroom.

PROCEDURE:

In order to calculate the relative humidity of an air sample it is necessary to know the vapor pressure of water at the temperature of the air sample and also the temperature at which the air sample becomes saturated with water vapor. This later temperature, called the dew point, can be found by rapidly evaporating some ether from a small metal container. As the ether evaporates it cools the sides of the container and subsequently the air that surrounds it.

When the air surrounding the container has been cooled to the dew point, water vapor will begin to condense on the cold surface. The temperature of the air at that point will be the same as the air temperature inside the container.

Measure the dew point temperature twice. If the two values are very close use the average value in your calculation for the relative humidity. If the two temperatures vary by more than two degrees, make a third measurement and average the three.

EXPERIMENTAL DATA:

Trial #	Room Temperature	Vapor pressure for saturated air at room T.	Dew Point Temperature	Vapor pressure for saturated air at the Dew Point Temperature
Average				

INTERPRETATION OF DATA:

$$\text{Relative Humidity} = \frac{\text{Absolute Humidity}}{\text{Capacity}}$$

$$= \frac{\text{VP at Dew Point Temperature}}{\text{VP at Room Temperature}}$$

$$\text{Relative Humidity} = \boxed{}$$

QUESTIONS:

1. If the dew point temperature of an air sample is the same as its room temperature what is the relative humidity of the air sample?

2. If a given air sample was heated in a closed container, what effect would the heating have on the dew point of that air sample?

3. Is it possible that the relative humidity could be greater than 100%? Explain.

4. Explain why a combination of high air temperature and low relative humidity is quite pleasant whereas high temperatures coupled with high relative humidity is so unbearable.

II. Man's Dependence upon the Atmosphere

A. Store House for Materials Involved in Cyclic Exchange Mechansims Essential to Life Processes

1. Oxygen

2. Carbon Dioxide

3. Water Vapor

B. Moderator of Energy Flow

1. Absorption of Ultraviolet by Oxygen

2. Absorption of Infrared by Carbon Dioxide and Water

3. Stabilization of Temperatures at the earth's Surface

C. Mechanisms for the Dilution of Waste

D. Medium for the Transport of Matter and Energy

1. Transport of Energy via Mechanical Waves

2. Support of Particles via Buoyant Force

E. Environmental Pressure System within Which Life Systems Function

1. Maintenance of the Liquid State of Matter

2. Work resulting From Pressure Differences

THE GROWING PROBLEM OF AIR POLLUTION

THE GROWING PROBLEM OF AIR POLLUTION

INTRODUCTION:

—Ed Nofziger, courtesy of PARADE

"HEY— IT'S POLLUTED UP HERE, TOO!"

The first sign of a city visible from an airplane on a clear day is a thick brownish-grey haze that envelops it. While flying above it one wonders how anyone could go on day after day, year after year, breathing such filthy air. On the ground, however, people do not notice anything unusual. The pollution of their atmosphere has developed gradually over a period of many years and they have become accustomed to it. Most people who live in the brownish-grey haze blame the weather for "just another overcast day" and go on about their business.

Air pollution has nonetheless begun to arouse the concern of the public. More and more cities in this country are recording an increasing frequency of days of severe "smog". In Los Angeles, the most notable smog afflicted community, public opinion has provoked offical action prohibiting domestic trash-burning and local industries have been compelled to make adjustments to minimize their contribution to the smog.

Other communities are beginning to follow suit in developing programs to cope with their pollution problems. Whether air pollution is to be endured as a nuisance or suppressed by vigorous civic action, it must be reckoned as an unpleasant and very expensive consequence of urban and industrial civilization.

As the population continues to increase in numbers and its demands for energy utilization and industrial productivity, we can expect the pollution problems in increasing numbers and severity - unless we do something about it!

Ways and means of controlling most forms of air pollution have been developed and people can insist that they be used. The cost of controlling air pollution is considerably less than the cost of property loss and damage resulting from air pollution. Control measures also pay off in more enjoyable life and better health. We have the know-how and the techniques to control most sources of air pollution. Thus far we have not had a society educated to understand or appreciate the seriousness of the problem and determined to do something about it while we still can.

Utilization of Natural Resources

THE GROWING PROBLEM OF AIR POLLUTION

Resource Material:

Required Reading:	The Battle for Clean Air, Public Affairs Pamphlet #403 "Air Pollution and Public Health", Scientific American Offprint #612 Science and Technology, June-July, 1969
Recommended Reading:	"Our Dirty Air", Science World, Nov. 4, 1965 "Menace in the Skies", Time, Jan. 27, 1967 "Poison in Our Air", Product Engineering, Dec. 19, 1966, reprint "We Can Afford Clean Air", Fortune, Nov., 1965 "There's Something in the Air", Redbook, August, 1966, reprint
Audio Tapes:	"Our Dirty Sky", Today's Health, March, 1966 CBS Report, Air Pollution, April 1967
AV Program:	The National Scandal of Air Pollution

QUESTIONS FOR CONSIDERATION:

1. What are the major types of pollutants found in the air as a result of man's activity?

2. Identify the major sources of air pollution.

3. What types of pollutants are found in the atmosphere as a result of natural processes, that is, processes that are not related to man's activities?

4. What is the estimated amount of "aerial garbage" being dumped into the U.S. atmosphere each year?

5. Discuss the types of damage that results from the polluted atmosphere.

6. What is the estimated annual cost that people within the United States are paying because of our air pollution problem?

7. Discuss the "Air Pollution Control Act" passed by Congress in 1963.

8. What is "smog"?

Identify the two major classifications of smog and discuss the differences between them.

9. Discuss three major air pollution episodes of the 20th Century.

10. What is the single largest contributor to our air pollution problem?

Can anything be dome about it?

What?

11. What is a "thermal inversion"?

What do thermal inversions have to do with air pollution?

Did thermal inversions occur before air pollution became a problem?

12. What do you consider to be the most serious aspect of our air pollution problem?

THE GROWING PROBLEM OF AIR POLLUTION

I. Factors responsible for the growing problem of air pollution

A. Incomplete combustion - the ultimate cause

B. Population growth

1. 1900
2. 1920
3. 1940
4. 1960
5. 1980
6. 2000

C. Urbanization trends and their implications

1. 1900

2. 1960

D. The Growth of Industrial Production

	1950	1960	1980	2000
Iron and Steel				
Chemical and Allied Products				
Petroleum Products				
Paper and Paper Board Production				
Research and Development				

II. Air Pollutants, Where are They Coming From

A. Extent of Pollution in the U.S.

B. Pollutants From Moving Sources (TRANSPORTATION)

1. Jet Airliners (Current/May 1968)

2. Motor Vechicles

a. Production Trends

1960

1967

1980

2000

b. Trends in Gasoline Comsumption

1960

1967

1980

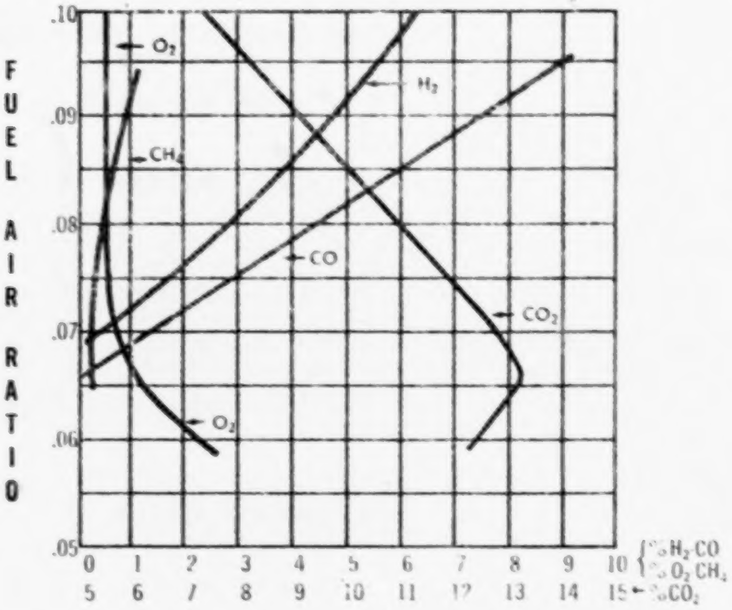
2000

c. Combustion of Gasoline

(1) complete oxidation (ideal)

$$\underset{\text{Iso-octane}}{2C_8H_{18}} + \underset{\text{Oxygen}}{25\,O_2} \longrightarrow \underset{\text{Carbon dioxide}}{16\,CO_2} + \underset{\text{Water}}{18\,H_2O}$$

27 molecules **34 molecules**



Variation of exhaust gas composition with fuel-air ratio

By permission of the Cambridge Instrument Co., Inc.

from: Chemistry and Petroleum, page 17

(2) incomplete combustion

(a) Major Products of Incomplete Combustion

carbon monoxide

nitrogen oxides

other hydrocarbons

d. Evaporation Losses

C. Stationary Sources

1. Manufacturing

2. Electric Power Generation

3. Space Heating

4. Disposal of Refuse

II. Classification of Pollutants

A. Man Generated Pollutants

1. acid anhydrides
    - (a) oxides of nitrogen
    - (b) oxides of carbon
    - (c) oxides of sulfur
2. other gases
3. particulate matter (solid pollutants)

B. Pollutants Generated as a Result of Natural Processes

1. terpenes
2. pollens
3. erosion products
4. volcanic eruptions

III. Thermal Inversions and Air Pollutants

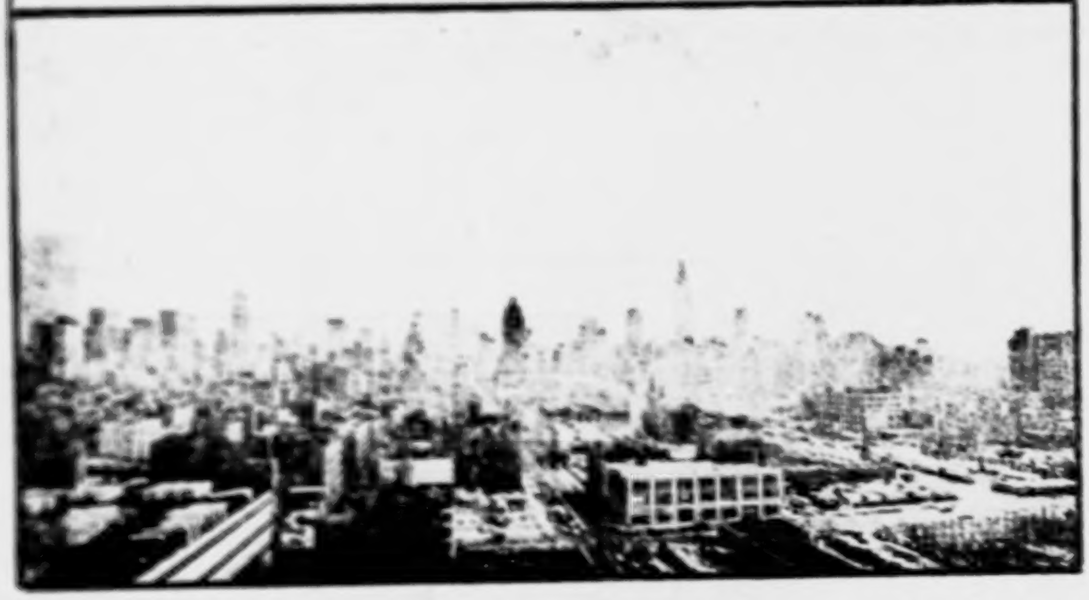
A. Characteristics of Thermal Inversions

1. Conditions which cause thermal inversions to occur

—THE NEW YORK TIMES

Above picture shows New York City at 9:30 a.m. last Thanksgiving Day, smothered by smog trapped by a mass of warm air hanging over the city. Below the same area is seen at 1:00 p.m. on the same day after a cold front and rising winds hit the city allowing clear air to break through.

—THE NEW YORK TIMES



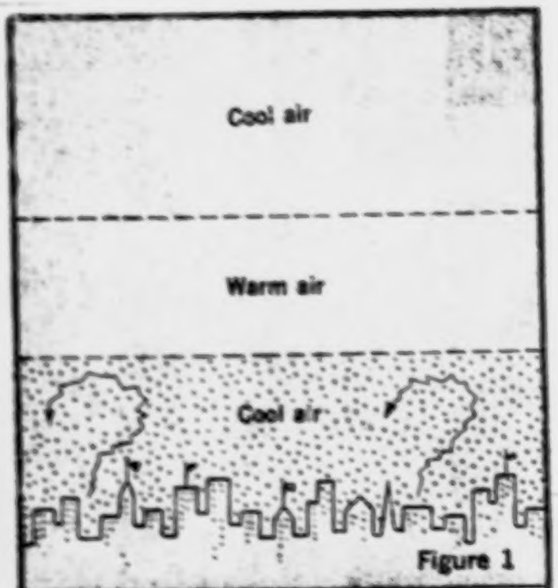


Figure 1

Temperature Inversion (Fig. 1)—Ground is cooled under clear skies, air sinks. Inversion Broken (Fig. 2) — Air is warmed by ground, air rises.

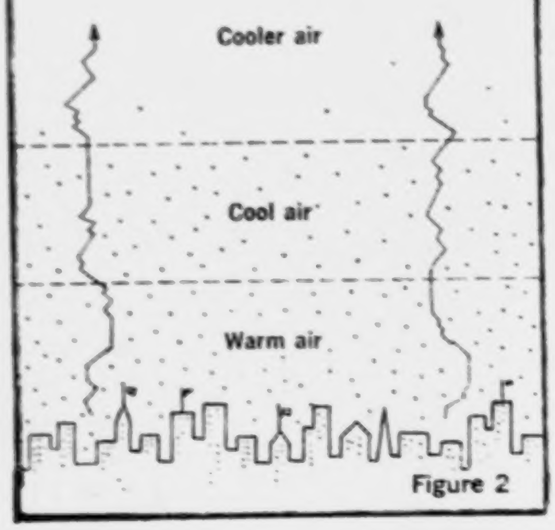


Figure 2

(a) convection currents

(b) land and sea breezes

C. Photochemical Reactions Within the Atmosphere

1. The Pollutants Involved in Photochemical Smog

Chemical Substance	Source

2. The Basic Photochemical Reactions in Los Angeles Type Smog

(a)

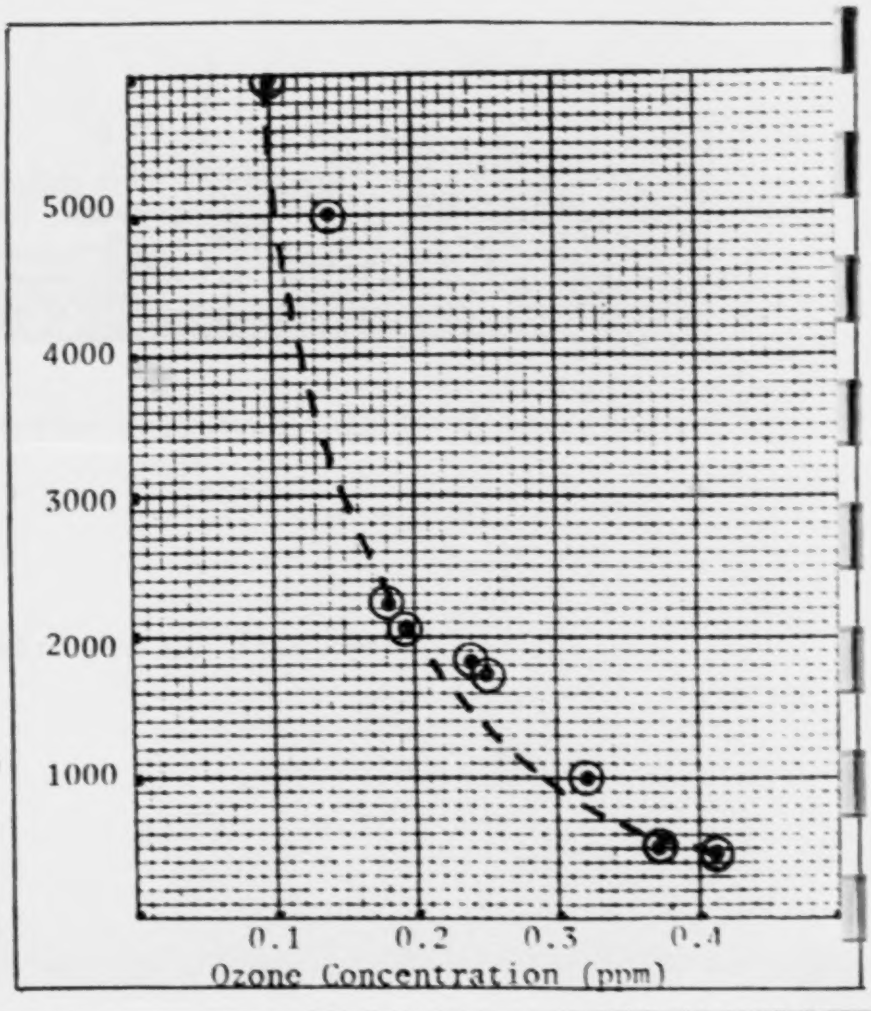
(b)

(c)

(d)

3. Ozone Production and Height of Inversion Base

Height (feet)	O_3 (ppm)
6000	0.1
5000	0.14
2200	0.18
2050	0.19
1810	0.24
1730	0.25
1000	0.32
490	0.37
430	0.41



4. Occurance of thermal inversions in the United States

   (a) location

   (b) frequency

B. Smog, the Result of Thermal Inversions

1. Difference between smog and fog

2. Classification of smogs

   (a) London type

   (b) Los Angeles type

Laboratory Investigation

FACTORS AFFECTING THE DISPERSEMENT OF POLLUTANTS DUMPED INTO THE AIR

INTRODUCTION:

The strong breezes associated with the movement of the great air masses over the continental United States regularly bring fresh air to most cities. In addition to the purging effect that these frontal systems have on the atmosphere, impurities dumped into the air are diluted by convection currents resulting from differences in air temperatures at different altitudes. Air near the earth's surface is warmed and rises, carrying pollutants away. When sunlight is absorbed at the earth's surface much of the energy is re-radiated, as heat, to the atmosphere. It is by this process of re-radiation that the air near the surface of the earth becomes heated. Since warm air is less dense than cold air there is a natural tendency for warm air to rise during sunlight hours.

Occasionally a layer of warmer air is formed above the cooler air near the ground. This condition is called a temperature or thermal inversion. The inversion acts like a lid on a pot. It prevents pollutants, being introduced into the air at lower levels, from rising and being dispersed. Consequently, pollutants build up to a point where an otherwise tolerable situation becomes a problem. The severity of the problem depends upon the length of time that the inversion condition persists.

In this laboratory investigation we shall attempt to duplicate the conditions of thermal inversion within a microatmosphere and study its effects upon pollutants introduced into the atmosphere.

PROBLEM:

To make a quantitative comparison of the rates at which pollutants accumulate in an atmosphere experiencing thermal inversion and for an atmosphere experiencing vertical updrafts resulting from convection currents.

THEORY:

Many of the gaseous pollutants in the atmosphere are acid anhydrides, that is, gases which form acids when they are dissolved in water. Carbon monoxide, carbon dioxide, sulfur dioxide, nitrous oxide, and hydrogen chloride are all examples of acid anhydrides.

When acid anhydrides are absorbed in water the change in the acidity of the solution can be determined by a technique known as pH measurement.

pH is a measure of the hydrogen ion concentration in water solution. The higher the hydrogen ion concentration the more acidic a solution is. The strongest acid solutions have hydrogen ion concentrations as high as 1×10^{-7} grams per liter of solution. The weakest aqueous acid solution would have a concentration slightly less than 7×10^{-7} gram of hydrogen ions per liter of solution. As a matter of convenience the strongest acid solutions are said to have a pH of 1.0 and the weakest acid solutions a pH of just under 7.0. All acid solution fall within the pH range of 1.0000 to 6.9999. Distilled water would have a pH of 7.0000.

The presence of ions in water solutions is what makes the solution a conductor of electricity. Chemically pure distilled water does conduct electricity, but not nearly as well as water solutions which are made acidic or basic. The pH of any solution can be quickly determined by measuring the ability of the solution to conduct electricity. An instrument which is designed to do this is called a pH meter.

Another method of determining the ion concentration of a solution is by titration. Titration employs the concept of equivalent weight. One equivalent weight of any acid in solution will neutralize one equivalent weight of any base in solution. (#Eq. of Acid = #Eq. of Base).

Since Equivalent Weight = Normality of Solution x Volume of Solution in Liters,

$$N_{acid} \cdot V_{base} = N_{base} \cdot V_{base}$$

a base of known normality can be titrated into a known volume of an acid solution. Having measured the volume of base solution required to neutralize the acid, the concentration of the acid can be calculated:

$$N_{acid} = \frac{N_{base} \cdot V_{base}}{V_{acid}}$$

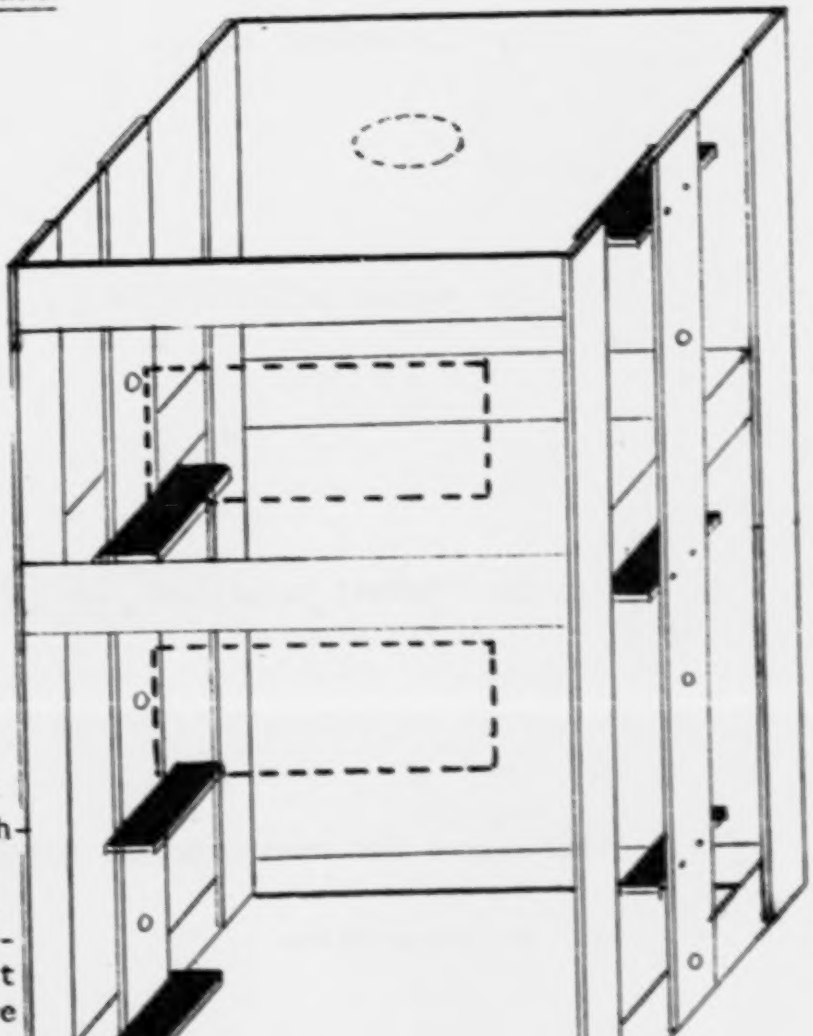
PROCEDURE:

The diagram shown represents an atmospheric model. Normal conditions of convection currents can be developed in the model by operating an electric heater at the base.

An inversion can be developed by placing a block of ice at the base of the model and a heat source at the top.

Pollutants in the form of HCl molecules can be introduced into the atmsophere by placing an open beaker of concentrated HCl solution at the base of the model.

Beakers containing equal volumes of water, placed at various levels within the model, will absorb HCl molecules. The rate of absorption will be directly proportional to the concentration of HCl pollutants present in the microatmosphere. Temperature gradiants within the microatmosphere will be determined by use of thermometers placed at regular intervals within the model.



Strength of Solutions

I. Methods of Describing the Strength of a Solution

A. Density

B. Percent Strength

1) solute

2) solvent

C. Introduction to "Equivalents"

1) Equivalent weight

2) Number of Equivalents

3) "Normal Solutions" and "Normality"

II. Techniques for Measuring the Strength of a Solution

A. By Evaporation

B. By Titration

1. The theory of titration

   a) Equivalent weights

   b) titrating standards

2. The techniques of titration

   a) use of the titrating buret

      (1) mounting

      (2) operation

      (3) reading scales

   b) operational techniques

      (1) selection of titrating standard

      (2) selection of indicator

      (3) initial titration

      (4) final titration

c) Care of the Buret

(1) cleaning

(2) storage

C. Use of the Dropping Pipette

a) types of dropping pipettes

b) transferring solutions

Lab Problem

Name ______________________

Science IIIB Hour _____

Date ______________________

Determination of Strength of Solution

INTRODUCTION:

The strength of a solution, in terms of its ion concentration, may be determined by applying the concept of "Equivalent Weight".

The equivalent weight of any material represents the quantity of that material which will react with any other material in a chemical reaction. For example, the equivalent weight of NaOH is 40. This means that 40 g of NaOH will react with one equivalent weight of any other substance in a chemical reaction.

If a solution contain 1 Equivalent weight of solute per liter of solution the strength of that solution is said to be 1 normal

$$N = \frac{\#Eq.}{\#1}$$

therefore; $\#Eq = N \cdot \#1$

Since things equivalent to the same thing are equivalent to each other;

$$[N \cdot \#1 = N \cdot \#1]$$

This fact is the basis of determining the strength of a solution, that is, the number of equivalents of solute it contains/liter. The process is called TITRATION. In this process the NORMALITY of an unknown acid or basic solution is determined by experimentally determining the volume of "titrating standard" (acid or base) required to exactly neutralize the unknown. Since one may choose the volume of unknown to be titrated and also the N or the titrating standard three of the factors in the titration equation are known.

"UNKNOWN" ACID		"TITRATING STANDARD" BASE
$[N \cdot VOL$	=	$N \cdot VOL]$
$N \cdot 4$ ml	=	$0.01 \cdot 36$

PROBLEM: Determine the normality of the acid solution provided.

DATA

# of sample	VOL UNKNOWN (ACID)	VOL OF TITRATING STANDARD USED (0.01N NaOH)
FIRST TITRATION		
SECOND TITRATION		
THIRD TITRATION		
AVG.		

INTERPRETATION OF DATA

(use avg. values)

CONCLUSION

# of sample

N = ___________

QUESTIONS

__________ 1. How many grams of NaOH would be required to prepare 1 liter of 0.01N solution?

2. Assume that 40 ml of 0.01N NaOH were required to neutralize 4 ml of an acid solution.

__________ a) What was the Normality of the acid?

__________ b) How many equivalents of this acid would be contained in 1 liter of the solution?

__________ c) If the acid was HCl (mol wt = 36.5) how many grams of HCl would be contained in 1 liter of the solution described above?

Problem Assignment

Name ______________________

Science IIIB Hour ________ 159

Date __________________

Ion Concentration in Solutions

Definitions:

1) Equivalent wt $= \frac{\text{formula wt}}{\text{valence}}$

2) Normality $= \frac{\text{\# equivalents}}{\text{\# liters}}$

3) Since things equivalent to the same thing (Hydrogen) are equivalent to each other.

$$N_{acid} \cdot V_{acid} = N_{base} \cdot V_{base}$$

1. Calculate the equivalent weight of Hcl

2. How many grams of $Al_2(SO_4)_3$ would be required to equal 1 equivalent wt of $Al_2(SO_4)_3$?

3. Calculate the normality of a solution which contains 40g of NaOH in 500 ml of water.

4. How many grams of NaOH would be required to prepare 500 ml of a 0.5 N solution of NaOH ?

5. How many equivalents of H_2SO_3 would it take to neutralize 140 ml of 0.5 N NaOH solution?

6. It was found that 60 ml of a 0.1N NaOH solution was required to neutralize 10 ml of an acid solution.

   A) what was the normality of the acid solution?

   B) if the acid was an H_2SO_3 solution how many equivalents of H_2SO_3 were in the solution?

Laboratory Investigation

Name ______________________________

Science IIIB Hour _____

Date ________________________

FACTORS AFFECTING THE DISPERSEMENT OF POLLUTANTS DUMPED INTO THE AIR

PURPOSE OF INVESTIGATION:

To make a quantitative comparison of the rate at which pollutants (HCl molecules) accumulate in an atmosphere experiencing, (a) updrafts resulting from normal convections, and (b) conditions of thermal inversion.

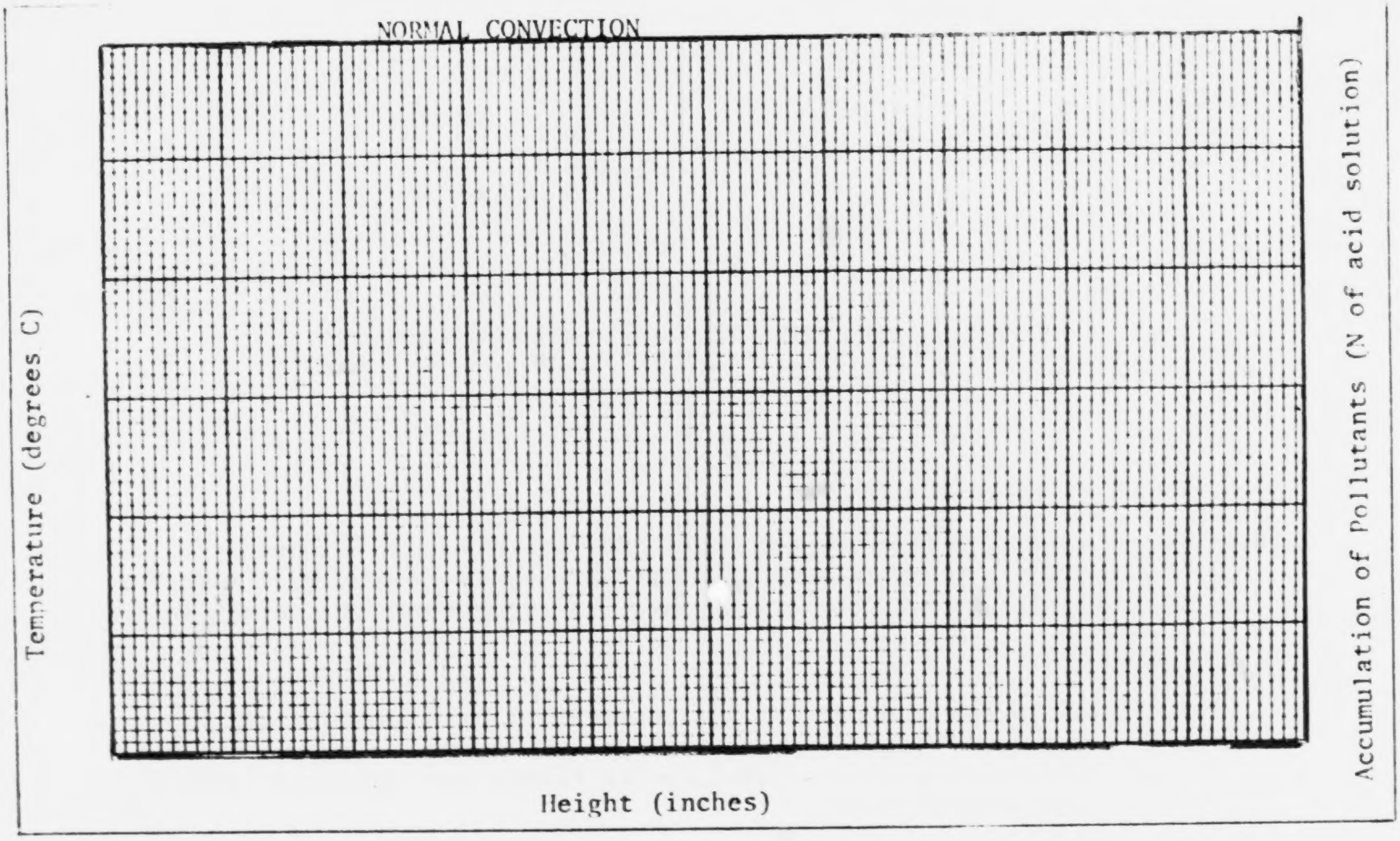
PROCEDURE:

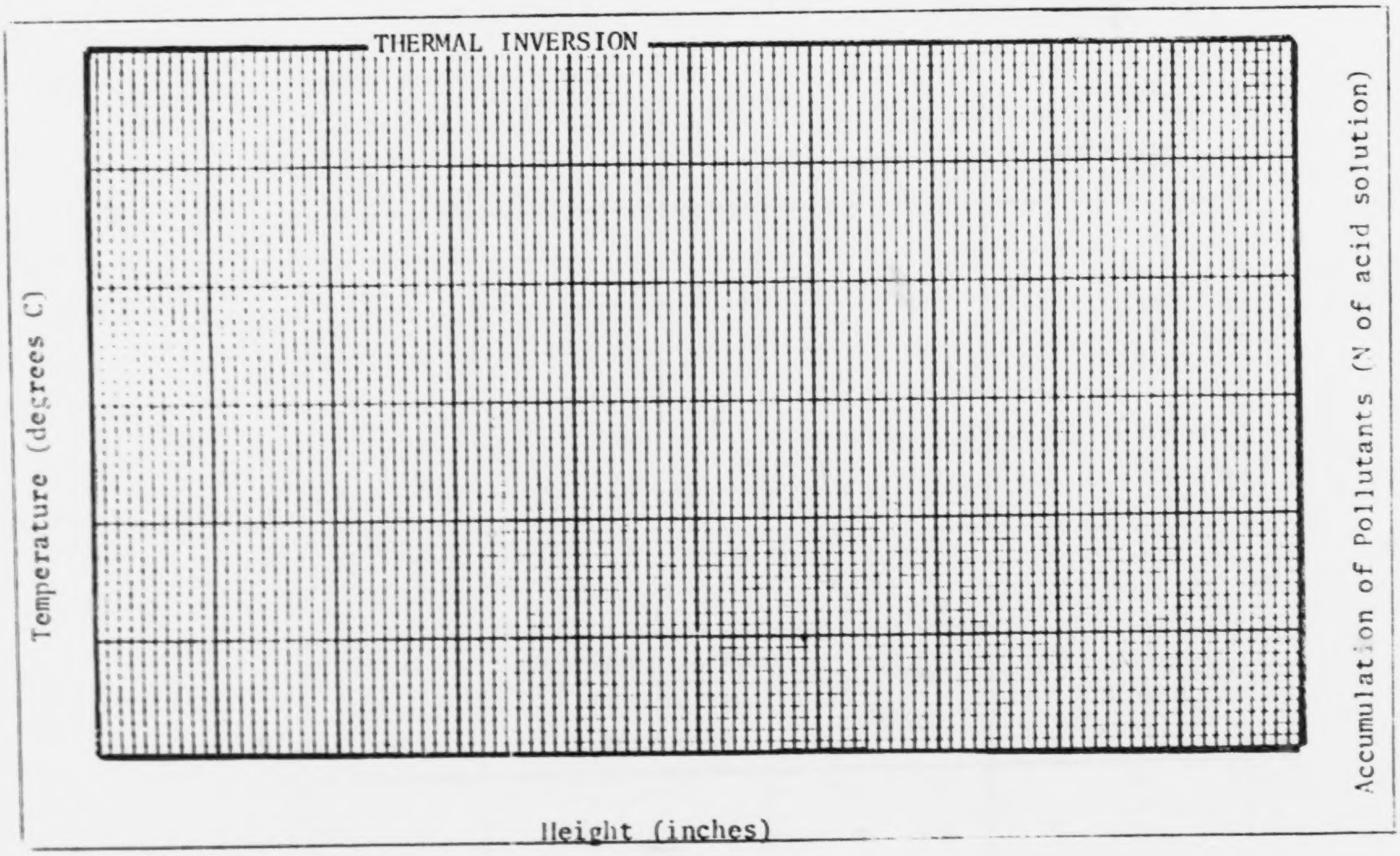
The microatmospheric model will be operated to maintain the conditions for (a) and then (b) for 24 hour periods. The accumulation of pollutants and air temperatures will be measured at twenty inch intervals throughout the microatmospheric model.

EXPERIMENTAL DATA:

	NORMAL CONVECTION		
HEIGHT (feet)	TEMP	Ml of .005 NaOH used	N of ACID
0			
1			
2			
4			
6			
8			
10			

	THERMAL INVERSION		
HEIGHT (feet)	TEMP	Ml of .005 NaOH used	N of ACID
0			
1			
2			
4			
6			
8			
10			





QUESTIONS:

1. How do thermal inversions compound the problem of air pollution?

2. Describe two different types of weather conditions which produce thermal inversions.

AIR POLLUTION AND PUBLIC HEALTH

I. Major Air Pollution Episodes of the 20th Century

A. Meuse Valley, Belgium, 1930

1. cause

2. duration

3. effects

B. Donora, Pennsylvania, 1948

1. cause

2. duration

3. effects

C. London, England, 1952

1. cause

2. duration

3. effects

II. The Effects of Air Pollution on Public Health

A. Difficulties in Defining the Health Effects of Air Pollution

1. disease and disease process

2. lack of controlled experimentation

B. Diseases Assoicated with Air Pollution

1. Respiratory Diseases

(a) bronchitis

(b) emphysema (Sci. Am. offprint #612)

(c) common cold

2. Lung Cancer

3. Lead Poisoning (Sc.World, Nov 4, 1965 and Sc. World, Oct. 28,1966)

PROBLEMS OF COEXISTENCE AND CONTROL

I. The Cost of Air Pollution (T^{II}, March 1966)

A. Physical and Material Losses Attributed to Air Pollution

Type of Loss	Estimated Annual Loss

B. Agricultural Losses

C. Losses in Wasted Resources

Laboratory Problem

Air Pollution, The Citizen's Role

CONDITION OF THE LOCAL ATMOSPHERE

INTRODUCTION:

It is the responsibility of every citizen living in this and future generations to become informed about the every increasing problems associated with the pollution of our air resource. "Free as air" is an expression which is no longer true. It is still true today that the air we breathe is free, that is, if we breathe unconditioned air. However, the time has come when man must either spend more money to develop and maintain programs designed to assure a continuing supply of fresh air or be ready to suffer the consequences of suffocating in his own wastes.

In this experiment we will make an analysis of the condition of the air within our own community. This analysis will provide the basis for analyzing our local pollution problem and, hopefully, suggest a course of action with respect to the citizens role in dealing with problems of air pollution.

THEORY:

The pollutants in the air can be divided into two classes, gaseous pollutants and particulate matter pollutants. Most of the gaseous pollutants are acid anhydrides. Their presence can be detected by bubbling polluted air through a water solution. Any acid anhydrides present will be dissolved in the water and decrease the pH of the solution. When an acid solution is mixed with a basic solution the acid and base tend to neutralize each other. Each becomes weaker. If equivalent amounts of acid and basic solutions are added together the resultant solution would be neutral. A quantitative measure of the pollutants present can be made by bubbling a known volume of polluted air into a flask containing distilled water and then titrating the solution with a basic standard to determine the number of equivalents of acid anhydride absorbed.
A normal solution is one which contains one gram atomic weight of solute per liter of solution. Sodium hydroxide (NaOH) is a compound which forms a basic solution when dissolved in water. It is commonly called lye. The molecular weight of NaOH is Na(23) + O(16) + H(1) = 40. If you were to dissolve 40 grams of NaOH in one liter of water you would have one liter of a 1N (normal) solution of NaOH. If 4 grams were dissolved it would be a 0.1N solution of NaOH.

HCl is an acid anhydride. Its molecular weight is 36.5. If 36.5 grams of HCl were dissolved in one liter of water, the solution would be a 1N solution of HCl. If 3.65 grams of HCl were dissolved in one liter of water, it would be a one liter solution of 0.1N strength of HCl.

Volumes of 1N acids are exactly equivalent to equal volumes of 1N bases. This means that if 100 cubic centimeters of any 1N acid were added to 100 cubic centimeters of any 1N base the resultant solution would be exactly neutral. Its pH would be 7.0000.

Let us assume that we were to place 1 liter of distilled water into a flask and then bubble several hundred cubic feet of polluted air through it. The acid anhydrides present in the air would be dissolved by the water and the pH of the solution would be shifted toward the acid range (below 7.0000). If exactly one gram equivalent weight of acid anhydrides were absorbed in this solution, the base present would be exactly neutralized.

The actual number of equivalents of acid anhydride dissolved in the process could be measured by titration.

$$N_{acid} \cdot V_{acid} = N_{base} \cdot V_{base}$$

Particulate matter, solid pollutants, could be captured by use of a filter trap used in conjunction with a pumping system. The weight of the particles per unit volume of air sampled could then be determined.

PROBLEM:

1. Design a system capable of measuring particulate matter as well as acid anhydrides present in the atmosphere.
2. Make a quantitative analysis of the air in this community for:
   a. particulate matter - g/1000 ft^3
   b. acid anhydrides - #Eq./1000 ft^3.

PROCEDURE:

Part I: Measurement of the Volume of Air Sampled

The filtered air leaving the system will be exhausted through a cylinderical tube. (Vol = A · l) The "length" of the cylinder is equivalent to the velocity with which the air is moved through the tube. Vel = distance/time and distance = vel. x time. Thus the volume of air sampled = area of exhuast tube x velocity of air flow x time of flow. The velocity of air flow will be measured with an instrument called an anemometer.

In order to use this equation to calculate the volume of air sampled during an extended period of operation it is not only necessary to measure the velocity of the air exhausted but also it must be established that the velocity of flow is constant. In this part of the experiment we shall measure the velocity with which filtered air is exhausted from the system over a period of 15 minutes.

Laboratory Problem

Name ______________________
Science IIIB Hour ____
Date ______________________

A QUANTITATIVE ANALYSIS OF THE POLLUTANTS PRESENT IN THE LOCAL ATMOSPHERE

(PART I)

PROBLEM:

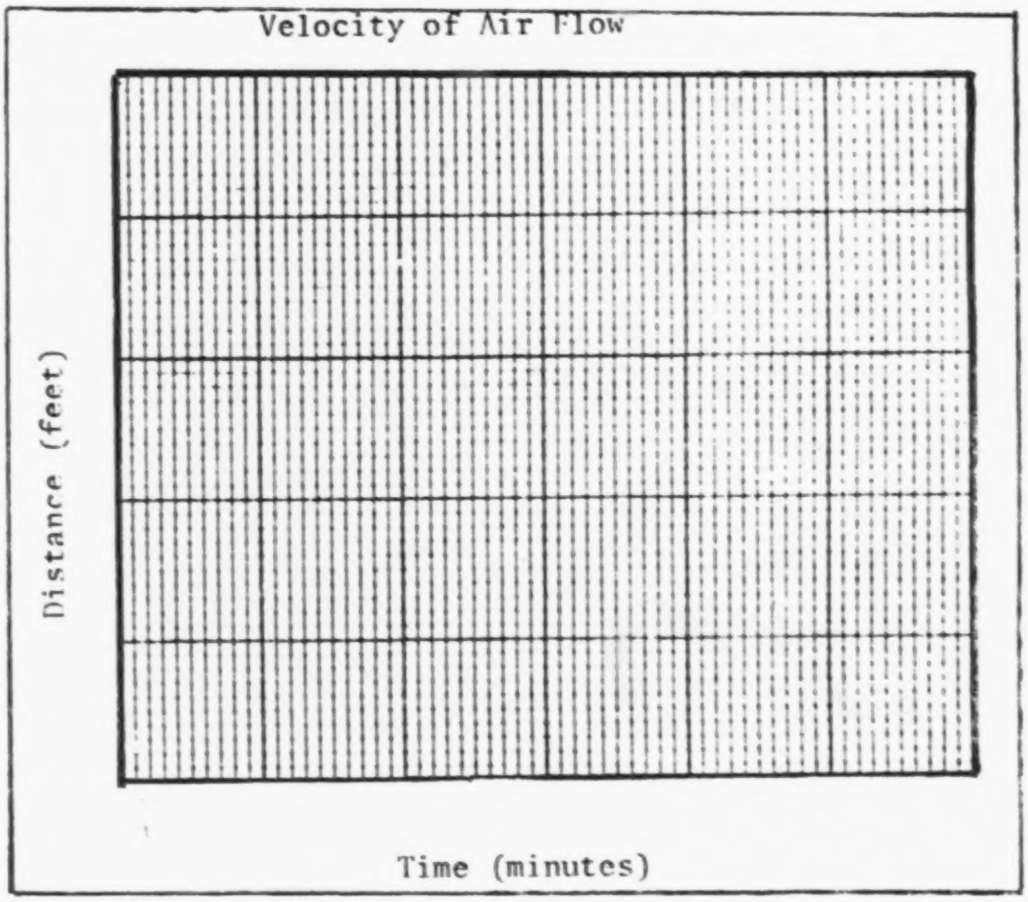
1. To measure the velocity with which filtered air is exhausted through the system.
2. To determine whether the velocity is constant.

PROCEDURE:

Use a "Brian's Type" anemometer to measure the flow rate of filtered air exhausted from the system. Construct a graph to illustrate the relationship of the distance the air moves per unit of time for a fifteen minute interval.

EXPERIMENTAL DATA:

TIME	DISTANCE
1 min	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	



INTERPRETATION OF DATA:

1. Average Velocity based on total time and distance -

2. Determine the slope of the line graph -

   a. change in "y" axis = ____________ ft.

   b. corresponding change in "x" axis = ____________ min.

   slope = ☐

QUESTIONS:

1. If the velocity of flow is constant what would be true about the slope of the line?

2. Using the average velocity calculated in part (1), above, determine the volume of air exhausted from the system in the 15 minute period. The diameter of the exhuast tube = 92 centimeters.

Laboratory Problem

Name _______________
Science IIIB Hour ___
Date _______________

A QUANTITATIVE ANALYSIS OF THE POLLUTANTS PRESENT IN THE LOCAL ATMOSPHERE

(PART II)

PROBLEM:

1. To determine the density of solid, particulate pollutants contained in the atmosphere in g/1000 feet^3.
2. To determine the concentration of acid anhydride in the atmosphere in # of Eq. of acid anhydride/1000 feet^3.

PROCEDURE:

The density of particulate matter in the air sampled will be determined by measuring the weight increase in the particle trap used to filter the air.

The concentration of acid anhydrides will be determined by bubbling the air sample through a 1N NaOH solution and titrating with a 0.1N HCl solution to find the number of equivalents of acid anhydride absorbed.

The analysis will be based on a continuous sampling of air over a 24 hour period.

EXPERIMENTAL DATA:

Specifications of Pumping System

diameter of exhaust tube _____
velocity of air flow _____
time of operation _____

Weather Data

Date: of test _______________

Cloud cover _______________
Air Temp (Aug) _______________
Precipitation _______________
Atmospheric Pressure (Sea level corrected) _______________

Particle Trap

original weight _____
final weight _____

Acid Anhydride Trap

initial vol. of distilled H_2O in trap _____
final vol. of solution in trap _____

Titration Data

normality of titrating sol. _____
vol. of titrating sol. used _____
vol. of trap solution used _____

ANALYSIS OF DATA: (show equations used and your substitution of numbers and units)

A. Volume of Air Sampled

☐

B. Grams of Particulate Matter per 400 ft^3 air

☐ per 400 ft^3

☐ per year

C. Normality of Trap Solution After Absorption of Acid Anhydrides.

☐

D. Concentration of Acid Anhydrides

☐

1. Change in N of trap solution due to absorption of acid anhydride recovered from air sample.

2. # equivalents of NaOH (trap solution) neutralized.

☐ per 400 ft^3

☐ per year

3. # equivalents of acid anhydride per 400 ft^3 of air.

QUESTIONS:

1. How would you rate the condition of the atmosphere in this community?

___ a. polluted ___ b. heavily polluted ___ c. slightly polluted

2. What specific acid anhydrides are probably present in the air sampled?

3. Were the pollutants in the air sampled under the influence of a thermal inversion during the collection period?

4. If a thermal inversion was in effect, the level of pollution would be abnormally:

___ a. high ___ b. low ___ c. not effected

II. The Fight Against Air Pollution

A. The Federal Role in Air Pollution

1. Public Law 159, 1955

2. The Clean Air Act, 1963

B. Budgets for Anti-Pollution Program

1. Federal

2. Local and State Agencies

C. Extent of Local Air Pollution Programs

1. The Los Angeles Story

2. Other Programs

D. The Citizens' Role

E. The Future Outlook

Some Basic Resources
Review

THE AIR

1. What are the major factors responsible for our air pollution problem?

2. Identify six major sources of air pollutants.

   Which one is the greatest contributor of pollutants?

3. What is the approximate weight of the pollutants dumped into the atmosphere in the United States annually?

4. What are the major types of air pollutants found in the atmosphere as a result of:

   a. mans activities -

   b. natural processes -

5. What causes thermal inversions and what do they have to do with the problems of air pollution?

6. What is the difference between Los Angeles and London type smogs?

7. What makes the Los Angeles type smog so objectionable?

8. What are the most objectionable acid anhydrides found in the atmosphere?

   What is their source?

9. Describe two different techniques which could be used to measure the amount of acid anhydrides present in the air.

10. Name three serious air pollution episodes which have occurred in the last three decades.

11. What diseases are now associated with the polluted atmosphere?

12. What is the estimated annual cost related to our polluted air?

Cite several examples of losses experienced as a result of air pollution.

13. Discuss the "Clean Air Act" passed by Congress in 1963.

14. Identify the gases contained in our atmosphere.

Give one important use for each.

15. Describe four basic physical properties of air.

16. Describe very briefly at least one characteristic of each of the seven layers of the earth's atmosphere.

17. Define relative humidity.

How is it measured?

What does it have to do with air pollution?

PERIODIC CHART

s d

LIGHT METALS TRANSITION

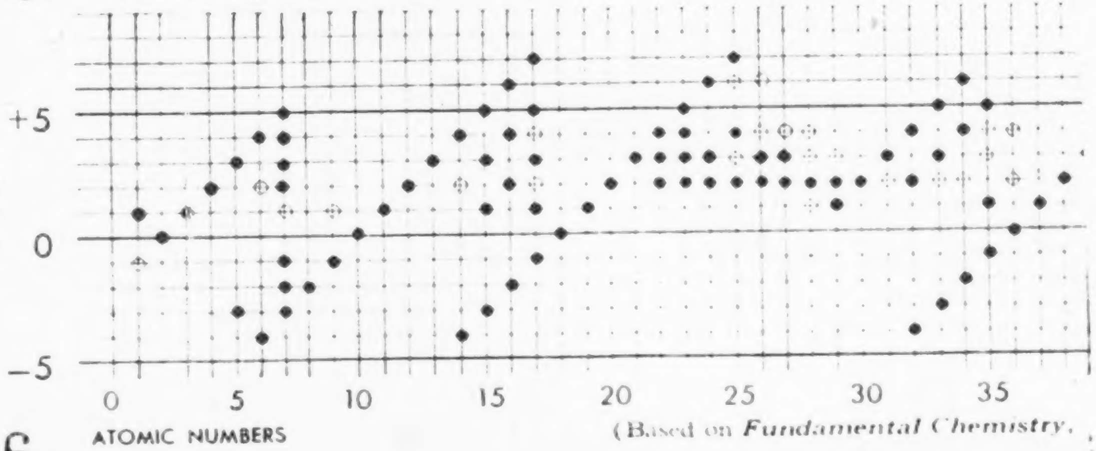
SHELLS PRINCIPAL QUANTUM No. *n*	SHELLS X-RAY NOTATION	I A	II A	III B	IV B	V B	VI B	VII B
1	K	1 1 H 1.00797						
2	L	2 1 3 Li 6.939	2 2 4 Be 9.0122					
3	M	2 8 1 11 Na 22.9898	2 8 2 12 Mg 24.312					
4	N	2 8 8 1 19 K 39.102	2 8 8 2 20 Ca 40.08	2 8 9 2 21 Sc 44.956	2 8 10 2 22 Ti 47.90	2 8 11 2 23 V 50.942	2 8 13 1 24 Cr 51.996	2 8 13 2 25 Mn 54.9380
5	O	2 8 18 8 1 37 Rb 85.47	2 8 18 8 2 38 Sr 87.62	2 8 18 9 2 39 Y 88.905	2 8 18 10 2 40 Zr 91.22	2 8 18 12 1 41 Nb 92.906	2 8 18 13 1 42 Mo 95.94	2 8 18 13 2 43 Tc (99)
6	P	2 8 18 18 8 1 55 Cs 132.905	2 8 18 18 8 2 56 Ba 137.34	57-71 See Lanthanide Series	2 8 18 32 10 2 72 Hf 178.49	2 8 18 32 11 2 73 Ta 180.948	2 8 18 32 12 2 74 W 183.85	2 8 18 32 13 2 75 Re 186.2
7	Q	2 8 18 32 18 8 1 87 Fr (223)	2 8 18 32 18 8 2 88 Ra 226	89-100 See Actinide Series				

6 P	LANTHANIDE SERIES (Rare Earth Elements)
7 Q	ACTINIDE SERIES

NOTE: A value given in parentheses denotes the mass number of the isotope of the longest known half-life, or of the best known one.

'The brackets are meant to indicate only the general order of subshell filling. The filling of subshells is not completely regular, as is emphasized by the use of red ink to denote shells which have electron populations different from the preceding element. In the case of He, subshell population is not by itself indicative of chemical behavior, and that element is therefore included in the *inert gas* group, even though helium possesses no p-electrons.

Open circles represent valence states of minor importance, or those



(Based on *Fundamental Chemistry,*

OF THE ELEMENTS

REVISED, 1964

p

INERT GASES

HEAVY METALS

NON METALS

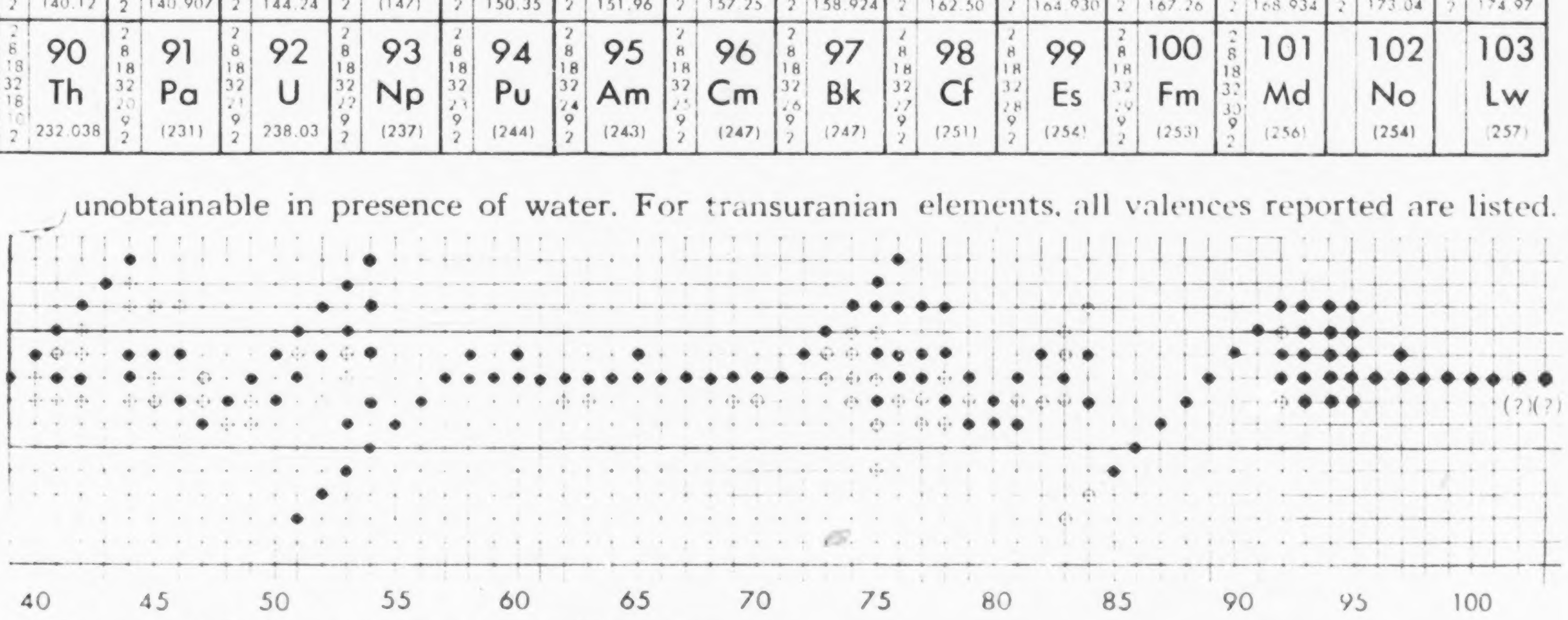
VIII						I B		II B		III A		IV A		V A		VI A		VII A			
																				2	2 He 4.0026
										2 3	5 B 10.811	2 4	6 C 12.01115	2 5	7 N 14.0067	2 6	8 O 15.9994	2 7	9 F 18.9984	2 8	10 Ne 20.183
										2 8 3	13 Al 26.9815	2 8 4	14 Si 28.086	2 8 5	15 P 30.9738	2 8 6	16 S 32.064	2 8 7	17 Cl 35.453	2 8 8	18 Ar 39.948
2 8 14 2	26 Fe 55.847	2 8 15 2	27 Co 58.9332	2 8 16 2	28 Ni 58.71	2 8 18 1	29 Cu 63.54	2 8 18 2	30 Zn 65.37	2 8 18 3	31 Ga 69.72	2 8 18 4	32 Ge 72.59	2 8 18 5	33 As 74.9216	2 8 18 6	34 Se 78.96	2 8 18 7	35 Br 79.909	2 8 18 8	36 Kr 83.80
2 8 18 15 1	44 Ru 101.07	2 8 18 16 1	45 Rh 102.905	2 8 18 18	46 Pd 106.4	2 8 18 18 1	47 Ag 107.870	2 8 18 18 2	48 Cd 112.40	2 8 18 18 3	49 In 114.82	2 8 18 18 4	50 Sn 118.69	2 8 18 18 5	51 Sb 121.75	2 8 18 18 6	52 Te 127.60	2 8 18 18 7	53 I 126.9044	2 8 18 18 8	54 Xe 131.30
2 8 18 32 14 2	76 Os 190.2	2 8 18 32 15 2	77 Ir 192.2	2 8 18 32 17 1	78 Pt 195.09	2 8 18 32 18 1	79 Au 196.967	2 8 18 32 18 2	80 Hg 200.59	2 8 18 32 18 3	81 Tl 204.37	2 8 18 32 18 4	82 Pb 207.19	2 8 18 32 18 5	83 Bi 208.980	2 8 18 32 18 6	84 Po (210)	2 8 18 32 18 7	85 At (210)	2 8 18 32 18 8	86 Rn (222)

d

f

2 8 18 18 9 2	57 La 138.91	2 8 18 19 9 2	58 Ce 140.12	2 8 18 21 8 2	59 Pr 140.907	2 8 18 22 8 2	60 Nd 144.24	2 8 18 23 8 2	61 Pm (147)	2 8 18 24 8 2	62 Sm 150.35	2 8 18 25 8 2	63 Eu 151.96	2 8 18 25 9 2	64 Gd 157.25	2 8 18 26 9 2	65 Tb 158.924	2 8 18 28 8 2	66 Dy 162.50	2 8 18 29 8 2	67 Ho 164.930	2 8 18 30 8 2	68 Er 167.26	2 8 18 31 8 2	69 Tm 168.934	2 8 18 32 8 2	70 Yb 173.04	2 8 18 32 9 2	71 Lu 174.97
2 8 18 32 18 9 2	89 Ac (227)	2 8 18 32 18 10 2	90 Th 232.038	2 8 18 32 20 9 2	91 Pa (231)	2 8 18 32 21 9 2	92 U 238.03	2 8 18 32 22 9 2	93 Np (237)	2 8 18 32 23 9 2	94 Pu (244)	2 8 18 32 24 9 2	95 Am (243)	2 8 18 32 25 9 2	96 Cm (247)	2 8 18 32 26 9 2	97 Bk (247)	2 8 18 32 27 9 2	98 Cf (251)	2 8 18 32 28 9 2	99 Es (254)	2 8 18 32 29 9 2	100 Fm (253)	2 8 18 32 30 9 2	101 Md (256)		102 No (254)		103 Lw (257)

unobtainable in presence of water. For transuranian elements, all valences reported are listed.



2nd Edition, by H. G. Deming, Published by John Wiley & Sons, Inc.)

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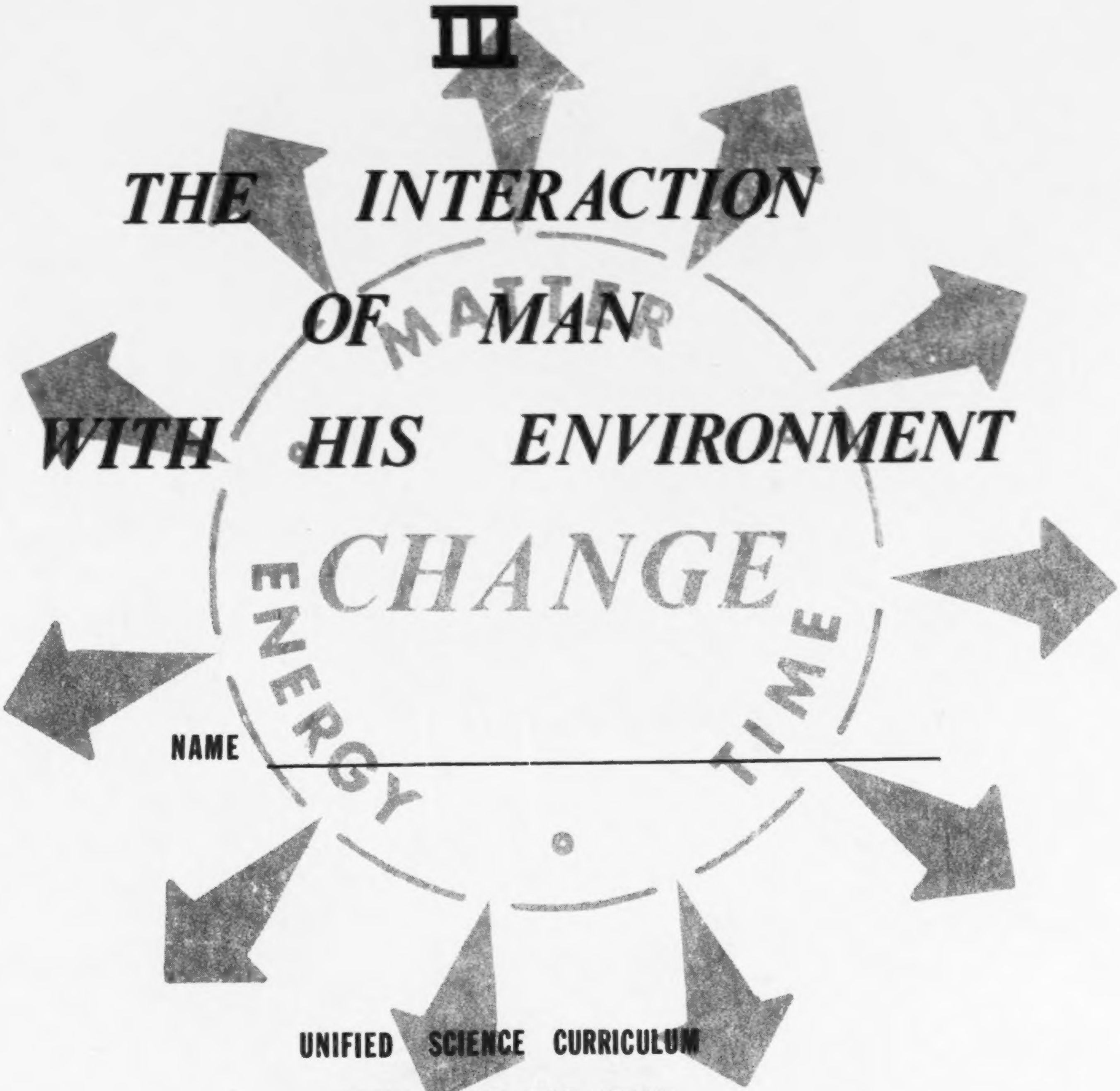
SCIENCE

III

THE INTERACTION OF MAN WITH HIS ENVIRONMENT

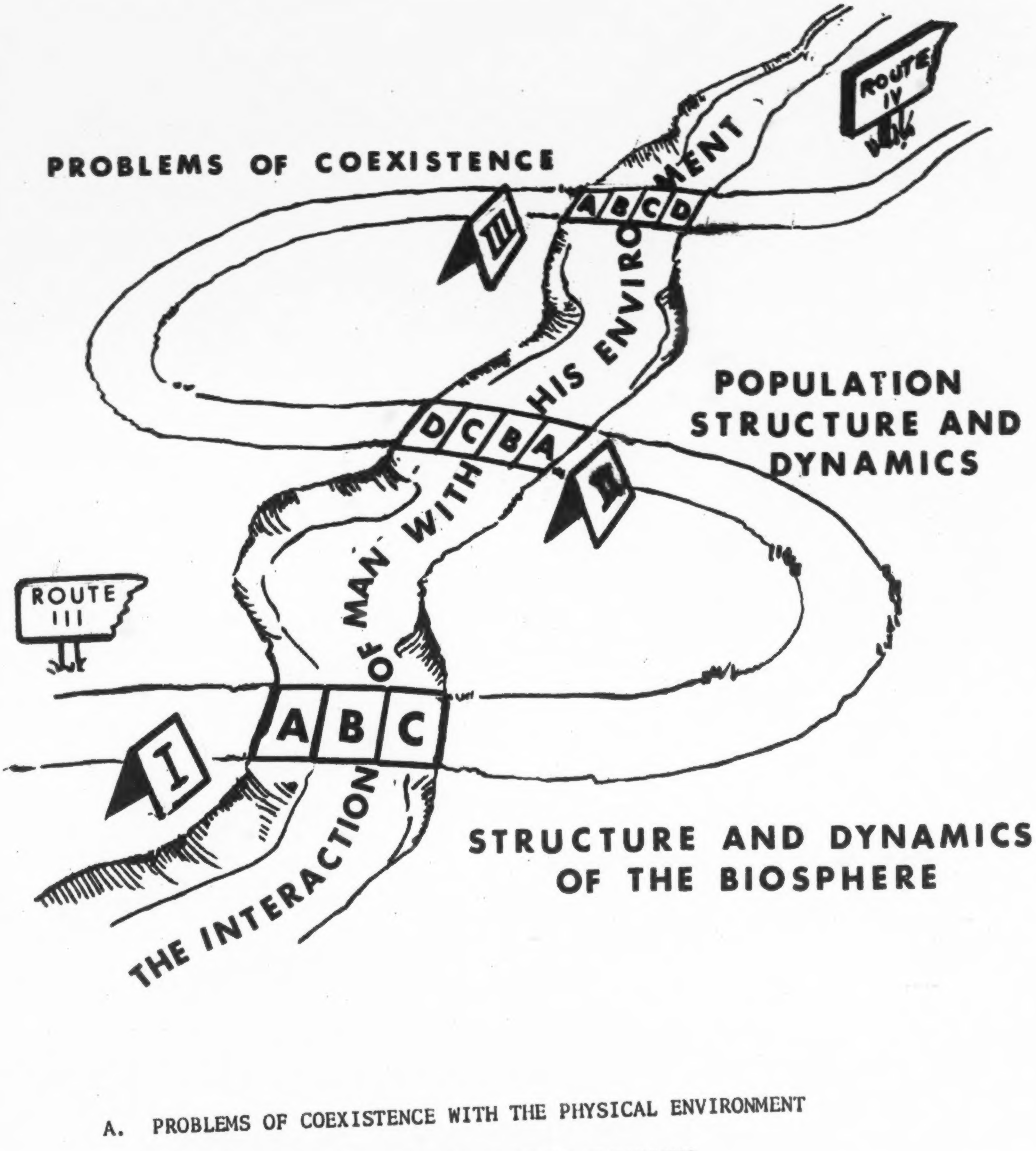


NAME ______________________________

UNIFIED SCIENCE CURRICULUM
MONONA GROVE HIGH SCHOOL
MONONA, WISCONSIN 53716
1968-69

SE 012 151
Part 2

SCIENCE IIIB


PROBLEMS OF COEXISTENCE
ROUTE IV
III
A B C D
THE INTERACTION OF MAN WITH HIS ENVIRONMENT
POPULATION STRUCTURE AND DYNAMICS
D C B A
II
ROUTE III
I
A B C
STRUCTURE AND DYNAMICS OF THE BIOSPHERE

A. PROBLEMS OF COEXISTENCE WITH THE PHYSICAL ENVIRONMENT

B. PROBLEMS OF COEXISTENCE WITH OTHER ORGANISMS

C. PROBLEMS OF COEXISTENCE WITHIN SOCIETY

D. SCIENCE AND THE EVOLVING SOCIETY

Problems of Coexistence with the Physical Environment

Utilization of Natural Resources (Contd.)

WATER

The Importance of the Water Resource

The Uniqueness of Water

The Distribution of Water

Society's Water Requirements

Problems of Water Pollution

Expansion of the Available Water Supply

WATER

Resource Material

Required Reading: Ours is the Earth, 551.1 So (SRC), pages 17-19

Life Science Library, Water, Introduction and pages 121-126.

(Audio tape available)

Recommended Reading: Life in the Ancient World, 901 (L), W76L

Water, Yearbook of Agriculture, 1955, 333.9 (L) Un5

Water, Land and People, 333 (L) F82

Water for the World, 333.9 (L) H47

Water, Roger Revelle, Scientific American, September 1963, pages 92-103.

QUESTIONS FOR CONSIDERATION:

1. Name four ancient civilizations which were considered powers in the then known world.
2. What one fact is true about any civilization?
3. What particular importance did water play in the Egyptian civilization?
4. Give a brief description on the utilization of water in the following:
   a. Mesopotania
   b. Egypt
   c. Greece
   d. Rome
5. In the Western Hemisphere there two ancient Indian civilizations which perished for lack of water. Describe briefly the water crisis of the Incas and the Aztecs.
6. What percent of an average sized human body is water?
7. What importance has water played in shaping the land?
8. List the uses that man has for water which might be considered under the broad heading industrial uses.
9. What makes water so important to industry?
10. Can an industrial power (country) remain so without water? Why?
11. Is there more water in the world now than there was a million years ago (time when man appeared on earth)? Explain.

BIBLIOGRAPHY

Battle Against the Sea, Lauber, Patricia, 914.92 L36 (E)

Death of the Sweet Waters, Carr, Donald E., 628 C31d

Downstream, Natural History of a River, Bardach, John

Our Plundered Planet, Osborn, Fairfield, 333 Os8

Rivers and Watersheds in America's Future, Helfman, Elizabeth, 333.9 H47r

The Sea Around Us, Carson, Rachel, 551 C23

This Thirsty World, Lewis, Alfred, 628.1 L67t (E)

The Water Crisis, Nikofaieff, George, Vol. 38, #36, 333.9 N69w

Water and Life, Milne, Louis and Margery, 551.4 M65w

Water and the Cycle of Life, Cocannover, Joseph A., 551 C65 c.2

Water for the World, Helfman, Elizabeth S., 333.9 H47

Water, Land and People, Frank, Bernard, 333 F82

Water or Your Life, Carhart, Arthur H., 333 C 27

Soil Savers, Colby, C.B., 333 C68 (E)

The Care of the Earth, Lord, Russell, 630.9 L86c

THE IMPORTANCE OF THE WATER RESOURCE

I. Water's Role in the Historical Development of Society

    A. Prehistoric Man

    B. Ancient Civilizations

        1. Mesopotamia

            a. Economic Dependence

            b. Cultural Emphasis

        2. Egypt

            a. Economic Dependence

            b. Culutral Emphasis

4

3. Greece

   a.

   b.

4. Rome

   a.

   b.

5. Others

II. Special Importance of Water
A. To Living System
1. Animals
a. Percentage

b. Functions

2. Plants
a. Percentage

b. Function

B. In Industry
1. Placement of Industries

2. Uses

C. In Agriculture

THE UNIQUENESS OF WATER

I. Molecular Structure

  A. The position of the oxygen orbitals

  B. The formation of the water molecule

    1. Initial phase

    2. Unequal distribution of charge

    3. Formation of the 105° angle

    4. The polar molecule (dipole) and the polar bond

  C. The Hydrogen Bond

II. Physical Properties of H_2O

A. Common or usual properties

B. Unusual physical properties

1. Boiling and freezing points

2. Solvent

a. Solutions

(1) Characteristics

(a)

(b)

(c)

(d)

(2) Parts

b. Suspensions

C. Surface tension

D. Tensile strength

E. Specific heat

F. Adhesion

G. Density of the solid state

III. Chemical Properties

A. Stability

B. Reaction with metal

C. Reaction with non-metals

D. Reaction with compounds

THE DISTRIBUTION OF WATER

I. The Hydrologic Cycle

A. Evaporation

1. Sources

2. Movement of evaporated water

B. Condensation

1. Types

2. Distribution

II. Global Distribution of Water

A. Fractional part of surface

1. Oceans

2. Fresh water

3. Ground water

B. Polar ice caps

C. Condensation

III. Manageable Water Supply

A. Meaning of term "manageable"

B. Source of "manageable" supply

C. The Supply of "manageable" water

D. The demand on "manageable" water

WATER MEASUREMENT TERMS

1 acre-ft = 325,851 gal
43,560 cu.ft.

1,000,000 gal = 3.07 acre ft.

1 cu. ft. = 7.48 gal

1 gal = 8.33 lbs.
231 cu. in.
.134 cu. ft.

1 T = 240 gal

FLOW

1,000,000 gal/day = 694.4 gal/min.
1.55 cu.ft./sec.
1,120 acre ft./yr.

Exercise

Name ______________________________

Science IIIB Hour _____

Date __________________________

THE DISTRIBUTION OF WATER

1. Basically, what is the problem that our nation must "face up to" with regard to our water resource?

2. Describe the process by which nature provides for a continuous supply of fresh water for man's use.

3. If it is true that there is essentially as much water in the world today as there ever was, since water is a "renewable" resource, why is there a water problem?

4. What is the average annual income of fresh water in the U. S.?

5. What is meant by the "manageable supply" of water?

6. What percent of the income of fresh water is theoretically manageable?

7. How much water is our nation currently withdrawing from our available supply? Of this amount what percent is actually used?

8. What is meant by the so-called problem of "distribution" with regard to our water resource?

9. Approximately how much water is actually used, in terms of gallons/day for all purposes in the United States?

10. How does the per capita usage in the U.S. compare to the world average?

11. What percent of the U.S. consumption of fresh water is used for:

(a) domestic purposes

(b) industrial purposes

(c) irrigation

12. How much does a gallon of water cost the average domestic consumer? the industrial user? the agricultural user?

13. How does the cost of water compare to the cost of other saleable liquid products?

SOCIETIES WATER REQUIREMENTS

I. The Economics of Water Utilization
  A. The demands
    1. Domestic

    2. Industrial

    3. Agriculture

    4. Production of Power

  B. The supply
    1. Domestic

    2. Industrial

    3. Agriculture

    4. Production of Power

II. The Year Two Thousand

A. Demands

1. Domestic

2. Industrial

3. Agriculture

4. Production of Power

B. The supply

1. Domestic

2. Industrial

3. Agriculture

4. Production of power

PROBLEMS OF WATER POLLUTION

I. Factors Effecting the Purity of Water

  A. Chemical

  B. Biological

II. Purity Requirements

  A. In Industry

    1. Hardness

    2. Hard water standards

  B. For domestic purposes

  C. In agriculture

III. What is "Polluted" Water!

  A. Industrial

  B. Domestic

  C. Agricultural

IV. Sources of Pollution

A. Industrial

B. Domestic

C. Agricultural

V. Methods of Purification

A. Natural

1. Cyclic

2. Percolation

3. Microbiological

B. Technological

Exercise

Name ______________________

Science IIIB Hour _____ 17

Date Due ________________

IMPURITIES IN WATER

1. What is meant by "chemically pure" water?

2. How does chemically pure water differ from "impure water"?

3. Discuss the difference between impure water and "potable" water.

4. What is the difference between potable water and "polluted water"?

5. How are the impurities found in water classified?

6. What class of impurities makes water non-potable?

7. Name three different kinds of elemental substances, found as impurities, in most ground water.

8. How do inorganic materials, present in solution, affect water?

9. What type of HARMFUL bacteria is commonly found in water polluted with organic impurities? What disease does this bacteria cause in man?

10. If water is polluted by organic impurities what compound is always found to be present to some degree?

11. How does an ion differ from an atom?

12. Name 7 different ions most likely to be found in ground water.

13. Identify and describe the usual procedures which are used to process the water supply of large cities.

14. How is chemically pure water prepared?

15. How could you treat water of unknown purity in order to make it safe for human consumption?

16. What kind of impurity in water, which renders water impotable, cannot be removed by present treatment procedures?

Laboratory Problem

MEASUREMENT OF ECOLOGICAL FACTORS IN WATER SAMPLES

PROBLEMS:

1. To determine the oxygen and carbon dioxide levels in a tap water sample and a pond water sample.
2. To determine the plankton content in the water samples.
3. To determine the bacteriological content of the water samples.

PROCEDURES:

Three 250 cc. water samples are collected by the method described by the teacher and tested as follows:

DISSOLVED OXYGEN: WINKLER METHOD

The first three steps described below must be performed in the field immediately after the sample has been secured. Any delay may result in error.

1. Remove the stopper from the 250 ml. sample bottle containing the sample to be analyzed and, by means of a long narrow volumetric pipette, add 2 ml. of manganous sulfate ($MnSO_4$) solution well below the surface of the water. In the same way add 2 ml. of the sodium hydroxide-sodium iodide (NaOH-NaI) solution.
2. Replace the stopper and mix the sample by inverting the bottle several times. Allow the precipitate to settle for a few minutes. Repeat the inversion; allow the settling of precipitate to leave a least 100 ml. of clear fluid in the upper portion of the bottle.
3. Using the cleaned slender volumetric pipette, add 2 ml. of concentrated sulfuric acid by permitting it to run down the neck of the bottle. Mix well by inverting the bottle several times.

   After the acid has been added and the stopper of the sample bottle replaced, the concluding steps of the analysis may be delayed, if necessary, for several hours iwthout appreciable change. Before titrating, reinvert the bottle for the even distribution of the contents.
4. Transfer 200 ml. of the sample to an Erlenmeyer flask and titrate rapidly with 0.023N sodium thiosulfate ($Na_2S_2O_3$) until the iodine color in the sample has been reduced to a pale straw color; then add 2 ml. of starch solution and continue the titration rapidly but carefully until the blue color first disappears. Stop the titration at this end point. Ignore any return of the blue color.

ANALYSIS OF THE DATA:

The number of ml. of $Na_2S_2O_3$ used is equal to the dissolved oxygen content in parts per million (ppm) and no additional calculation is necessary.

FREE CARBON DIOXIDE TEST

Since free carbon dioxide escapes from water so readily it is highly desirable that the analysis be made immediately after the sample is secured.

PROCEDURE:

1. Pour 100 ml. into a graduated cylinder. Do not agitate the sample while doing this.
2. Add 10 drops of phenolphthalein indicator. If the sample turns red, free carbon dioxide is absent; if colorless, proceed to step 3.
3. Add .0228 N NaOH from a burette, stirring gently during titration, until a faint permanent pink color appears and lasts for 30 seconds, when you look down through the sample at a white piece of paper.

ANALYSIS OF DATA:

The amount of free carbon dioxide, expressed in parts per million, is calculated by multiplying by 10 the number of ml. of NaOH used in the titration.

BACTERIOLOGICAL AND ANIMAL CONTENT

1. Place 15 ml. of the water sample in a Durham fermentation tube. Incubate for 24 hours.
2. After the 24 hour period, check for gas in the inner test tube. Remove a loop of the culture and plate it out on an agar plate. Incubate the original and agar plate for twenty-four hours.
3. Report on the growths in the Durham tube and the agar plate. Make slides and stain the organisms for examination under a microscope.
4. Weigh a filter paper. Then filter the water sample. Dry the filter paper in a steam bath and weigh again. Report the organic content of the water in grams.

QUALITATIVE ANALYSIS OF GROUND WATER

INTRODUCTION:

One of the most important properties of water is its ability to dissolve substances. For this reason water, which falls to the earth in one form of precipitation or another, dissolves various minerals as it filters through the crust of the earth and moves in underground rivers and reservoirs.

These dissolved materials alter the color, odor, and taste of water. Some of the solutes which effect the purity of ground water are desirable while others such as the "carbonates," which make water "hard," present costly problems for the consumer.

The mineral solutes most commonly found in the ground water of this area are Calcium, Magnesium, Iron which appear as Ca^{++}, Mg^{++}, and Fe^{+++}, metallic "cations" in the water solution.

The non-metallic "anion" counterparts of these "cations" are usually Sulfates SO_4^{--}, Carbonates or bicarbonates CO_3^- or HCO_3^-, and Chlorides Cl^-.

Water which contains a high degree of dissolved organic matter usually contains traces of the metallic NH_4^+, Ammonium ion. Ammonia is one of the products of decay in the nitrogen cycle when organic matter decomposes. Water contaminated by sewage always contains ammonia in solution. Although the amount may be too small to be detected by the characteristic odor of ammonia its presence may be confirmed by a positive reaction with certain chemical reagents. A positive reaction to the test for the ammonium ion means that a bacterial analysis of the sample should be made to determine if the water is polluted.

The dissolved particles in a "true solution" are molecular in size and cannot be removed by processes of filtering, also, these particles are too small to be directly observed in the solution. It is possible, however, to cause soluble ions to "clump" together to form insoluble precipitates which are visible in the solution.

The color of the precipitate, as formed under controlled experimental conditions, may serve as a means of identifying various ions.

An experimental method which makes use of this principle to identify various ions in solution is called Qualitative Analysis.

We shall devise a "scheme" of qualitative analysis, based on known rules of solubility, that will enable us to detect the presence of the ions common in ground water, namely: Mg^{++}, Fe^{+++}, Ca^{++}, NH_4^+, Cl^-, SO_4^{--}, CO_3^{--}.

Keep in mind the fact that the basic principle of the analysis is one of separation of ions and the identification of the ions separated. Thus we need to devise a scheme which will allow us to isolate each of the ions in turn, from a solution which contains all of them.

THE SOLUBILITY RULES

The chlorides, bromides, and iodides of all metals except lead, silver, and mercury (I) are soluble in water. The water-insoluble chlorides, bromides, and iodides are also insoluble in dilute acids.

The sulfates of all metals except lead, mercury (I), barium, and calcium are soluble in water. Silver sulfate is slightly soluble. The water insoluble sulfates are also insoluble in dilute acids.

All sodium, potassium, and ammonium salts are soluble in water.

The Nitrates, chlorates and acetates of all metals are soluble in water.

The carbonates, phosphates, borates, sulfites, chromates, and arsonates of all metals except sodium, potassium, and ammonium are insoluble in water, but soluble in dilute acids.

The hydroxides of sodium, potassium, and ammonium are very soluble in water. The hydroxides of calcium and barium are moderately soluble in water. The oxides and hydroxides of all other metals are insoluble.

SUGGESTED PROCEDURES FOR THE ANALYSIS OF CATIONS

Water solution containing: Mg^{++}, Ca^{++}, Fe^{+++}, NH_4^+

STRENGTH OF SOLUTIONS

A solution which contains a large amount of solute in a relatively small amount of solvent is said to be a concentrated solution. Conversely a solution which contains a small amount of solute in a relatively large amount of solvent is said to be a dilute solution.

These terms, concentrated and dilute are only descriptive since they do not tell us exactly what the ratio of solute to solvent is in the solution. In our work we will be concerned with the exact ratios of solute to solvent. In other words we will want to know the exact concentration of solutions.

One of the most convenient methods of describing the strength of concentration of solutions is in terms of the number of moles of solute contained in a given volume of solution. A solution which contains one gram molecular weight (mole) of solute in enough water to make one liter of solution is called a 1 M (molar) solution. The strength of any solution in terms of molarity may be determined by use of the following equation.

$$M = \frac{\text{moles of solute}}{\text{liters of solution}}$$

Below is a list of the chemical reagents, together with their molarities which will be used in the analysis of ground water. Complete the chart.

Reagent	# of moles required to prepare 250-ml of sol'n	Molecular weight	# of grams of solute needed to prepare 250-ml of sol'n
2M NH_4Cl			
15M NH_4OH			
2M HCl			
.2M KSCN			
.2M $(NH_4)_2C_2O_4$			
5M NH_4OH			
.2M Na_2HPO_4			
.2M $Ba(NO_3)_2$			
.2M $AgNO_3$			
3M HNO_3			
.5M $(NH_4)_2MoO_4$			

Name ____________________ 24

Exercise

Science IIIB Hour ______

Date Due ____________________

STRENGTH OF SOLUTION

I. Find the molecular weights of the following compounds.

Ex H_2SO_4 (1x2) + (32x1) + (16x4) = 2 + 32 + 64 = 98

1. NH_4Cl
2. HCl
3. KSCN
4. Na_2HPO_4
5. HCl
6. NH_4OH
7. $(NH_4)_2C_2O_4$
8. $Ba(NO_3)_2$
9. $AgNO_3$
10. $H\ NO_3$
11. $(NH_4)_2MoO_4$

II. Determine the number of moles required to make 250 ml of

1. 5M NH_4Cl
2. .5M HCl
3. 5M NH_4OH
4. .2M $AgNO_3$
5. 3M HNO_3

Ex.

$$\frac{2M\ NH_4Cl}{1000ml} = \frac{x}{250\ ml}$$

$$1000ml \cdot x = 250\ ml \cdot 2M\ NH_4Cl$$

$$x = \frac{250\ \cancel{ml} \cdot 2M\ NH_4Cl}{1000\ \cancel{ml}}$$

$$x = .5\ moles\ NH_4Cl$$

QUALITATIVE ANALYSIS OF GROUND WATER

PROCEDURE #1: Separation of Fe^{+++} from Mg^{++}, Ca^{++}, and NH_4^+

When NH_4Cl and excess NH_4OH are added to a solution containing Iron III and Magnesium the iron is precipitated as $Fe(OH)_3$. The addition of the NH_4Cl is to prevent the precipitation of Magnesium. *(sol rule for hydroxides indicates that both Fe and Mg hydroxides are insoluble).

The presence of the NH_4Cl in the solution provides an abundance of NH_4^+ ions which reduces the concentration of the OH^- ions to a point where $Mg(OH)_2$ will not form. This technique is called a point where $Mg(OH)_2$ will not form. This technique is called "Shifting The Equilibrium". $Fe(OH)_3\downarrow$ is so insoluble that the iron will precipitate even in the presence of a small number of OH^- ions.

Place 6 drops of the water solution to be tested in a clean test tube. Add 4 drops of 2M NH_4Cl and mix thoroughly. Add just enough 5M NH_4OH, drop-wise, with constant stirring, to make the solution alkaline. Then add one more drop of the 5M NH_4OH. *Use a stirring rod to transfer solution to a piece of litmus paper when testing the alkalinity of the solution.

If Fe^{+++} is present an orange-brown precipitate, $Fe(OH)_3\downarrow$ should form. To confirm that the precipitate is iron and not Mg hydroxide we may separate the insoluble precipitate and apply a second test for Fe.

PROCEDURE #2: Dissolve the Precipitate Suspected to be $Fe(OH)_3\downarrow$

Centrifuge the solution from Proc. 1 and "decant" the clear liquid into a clean test tube. This decantate should be set aside and saved for Proc. #4. Add 6 drops of 2M HCl to the residue in the tube. This will dissolve the $Fe(OH)_3\downarrow$ and allow you to obtain Fe^{+++} ions in sol.

PROCEDURE #3: Confirmatory Test for Fe.

Add 2 drops of 0.2M KSCN (potassium thiocyanide). The formation of a "blood red" precipitate confirms the presence of Fe.

PROCEDURE #4: Separation and Detection of Magnesium. $(MgNH_4PO_4)\downarrow$

Treat the solution saved from Proc. 1 with 1 drop of 5M NH_4OH and 4 drops of 0.2M Na_2HPO_4 (sodium biphosphate) mix well, warm gently, and allow to cool for 1 min. The formation of a white, precipitate indicates the presence of Magnesium. If no precipitate forms, heat to boiling and cool. If no precipitate forms Magnesium is absent. Centrifuge and decant the clear liquid into a clean test tube.

PROCEDURE #5: Detection of Calcium.

Add four dropt os 0.2M $(NH_4)_2C_2O_4$ (ammonium oxalate) to the decantate from procedure 4. If Calcium is present the Ca^{++} ion should combine with the C_2O_4 iron to form the insoluble $CaC_2O_4\downarrow$ white precipitate.

PROCEDURE #6: Detection of the ammonium ion; NH_4^+

Since the ammonium ion, NH_4^+, has been added to the test solution at several points in the analysis it is obvious that the solution from Proc. 5 does contain NH_4^+. For this reason a fresh sample of the original supply will be used in the test for the ammonium ion.

Place 15 drops of the original water sample in a clean test tube. Add 3 drops of Nessler Reagent, (K_2HgI_4; potassium iodomercurate). An orange precipitate, $(NH_4)_2HgI_4$; confirms the presence of the NH_4^+ ion.

If no precipitate forms heat the solution gently (Do Not Boil). If no precipitate forms the ammonium ion is not present.

ANION ANALYSIS OF GROUND WATER

PROCEDURE #7: Test for the Presence of the CO_3^{--} ion.

Place 10 drops of the water sample to be tested in a clean test tube. Add 6 drops of 2M HCl. Effervescence, and the evolution of CO_2 gas indicates the presence of the CO_3^{--} ion.

PROCEDURE #8: Test for the Presence of the HCO_3^- ion.

Place 20 ml of the water sample to be tested in a small beaker and boil for 5 min. Allow the solution to cool, stir thoroughly, and add 15 drops of the solution to clean test tube. Centrifuge for 1 minute and decant the clear liquid, carefully, into a clean test tube. The decantate, which may contain PO_4^{---}, SO_4^{--}, or Cl^- ions should be saved for further analysis in procedure #10.

The bi-carbonate ion, HCO_3^-, forms rather unstable, soluable, compounds. If such compounds are present in the water solution they will be decomposed by heat during the boiling process, to form CO_3^{--} ions which will combine with Ca^{++}, Mg^{++}, or Fe^{+++} ions which may be present in the solution.

$$(HCO_3^-) + \Delta = CO_3^{--} + CO_2 \nearrow$$

$$Ca^{++} + CO_3^{--} = CaCO_3 \searrow$$

PROCEDURE #9: Confirmation for the Presence of the HCO_3^- in the Original Solution.

Add 2M HCl, drop-wise, to the residue obtained in Proc. 8. Effervescence and the escape of $CO_2\nearrow$ gas confirms the presence of the CO_3^{--} ion found by the decomposition of HCO_3^- ions.

PROCEDURE #10: Separation and Detection of the PO_4^{---} ion.

Acidify the decantate from Procedure 8 with 3M HNO_3 (nitric acid) added drop-wise to the solution. Add 8 drops of ammonium molybdate sol. $(NH_4)_2MoO_4$. mix thoroughly, and heat carefully, without boiling.

The formation of a finely divided precipitate of ammonium phosphomolybdate $[(NH_4)_2PO_4\ 12MoO_3]$ takes place most readily at a temperature of 60 deg.C. in the presence of excess nitric acid.

Add 1 more drop of 3M HNO_3 to the warm solution and centrifuge immediately. The accumulation of a yellow precipitate, confirms the presence of the PO_4^{---} ion.

Decant the clear liquid into a clean test tube and save for analysis by Procedure #11.

PROCEDURE # 11: Separation of the SO_4^{--} ion.

Add 4 drops of 0.2M $Ba(NO_3)_2$ (Barium Nitrate) to the decantate from Proc. 10. The formation of a white precipitate, $BaSO_4\downarrow$, indicates that the SO_4^{--} ion may be present. Centrifuge and decant the clear liquid into a clean test tube and save for Proc. 13.

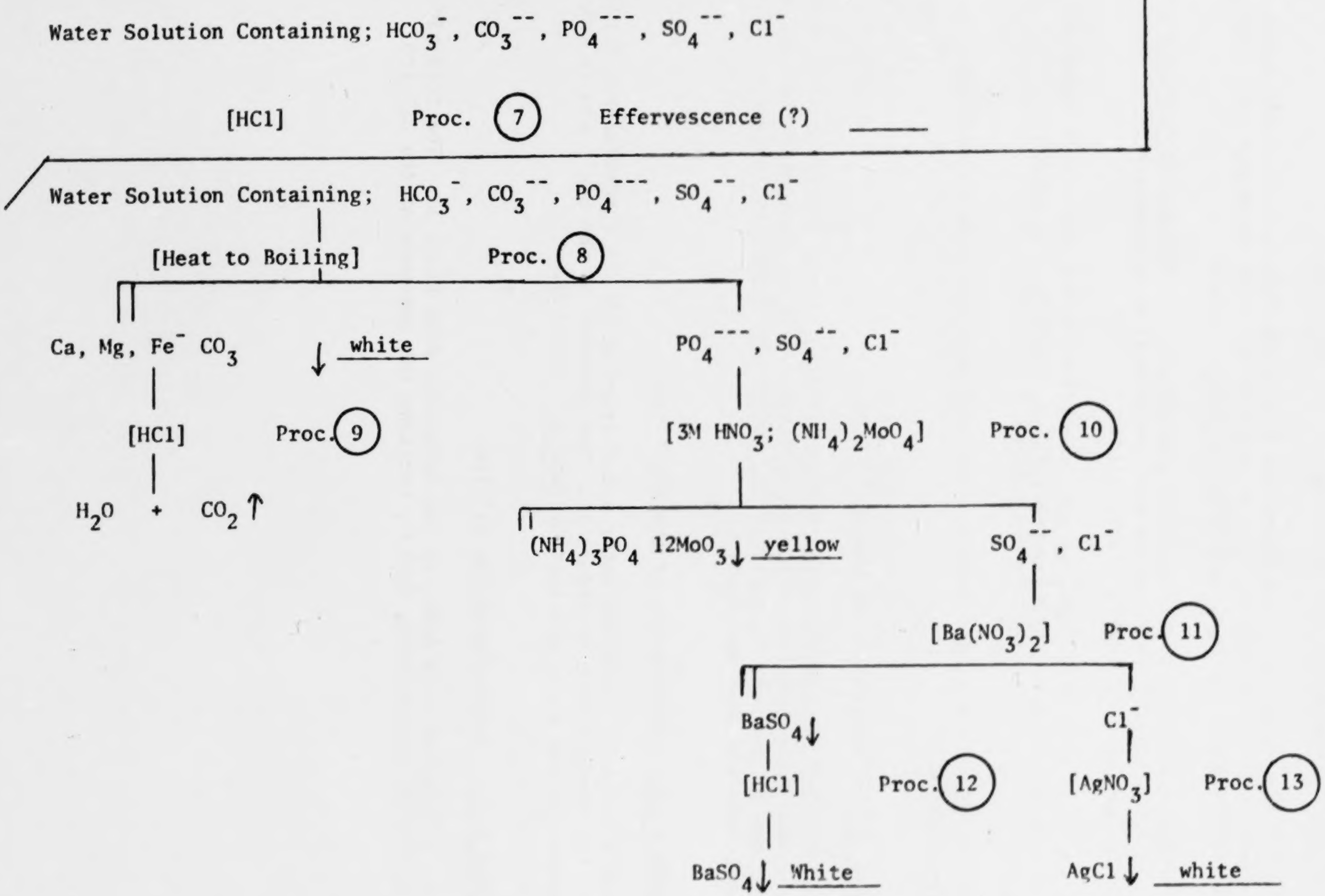
PROCEDURE # 12: Confirmation of the SO_4^{--} ion.

Add 5 drops of distilled water and 2 drops of 2M HCl (hydrochloric acid) to the residue from Procedure 11. The presence of the SO_4^{--} ion is confirmed if the white precipitate does not dissolve.

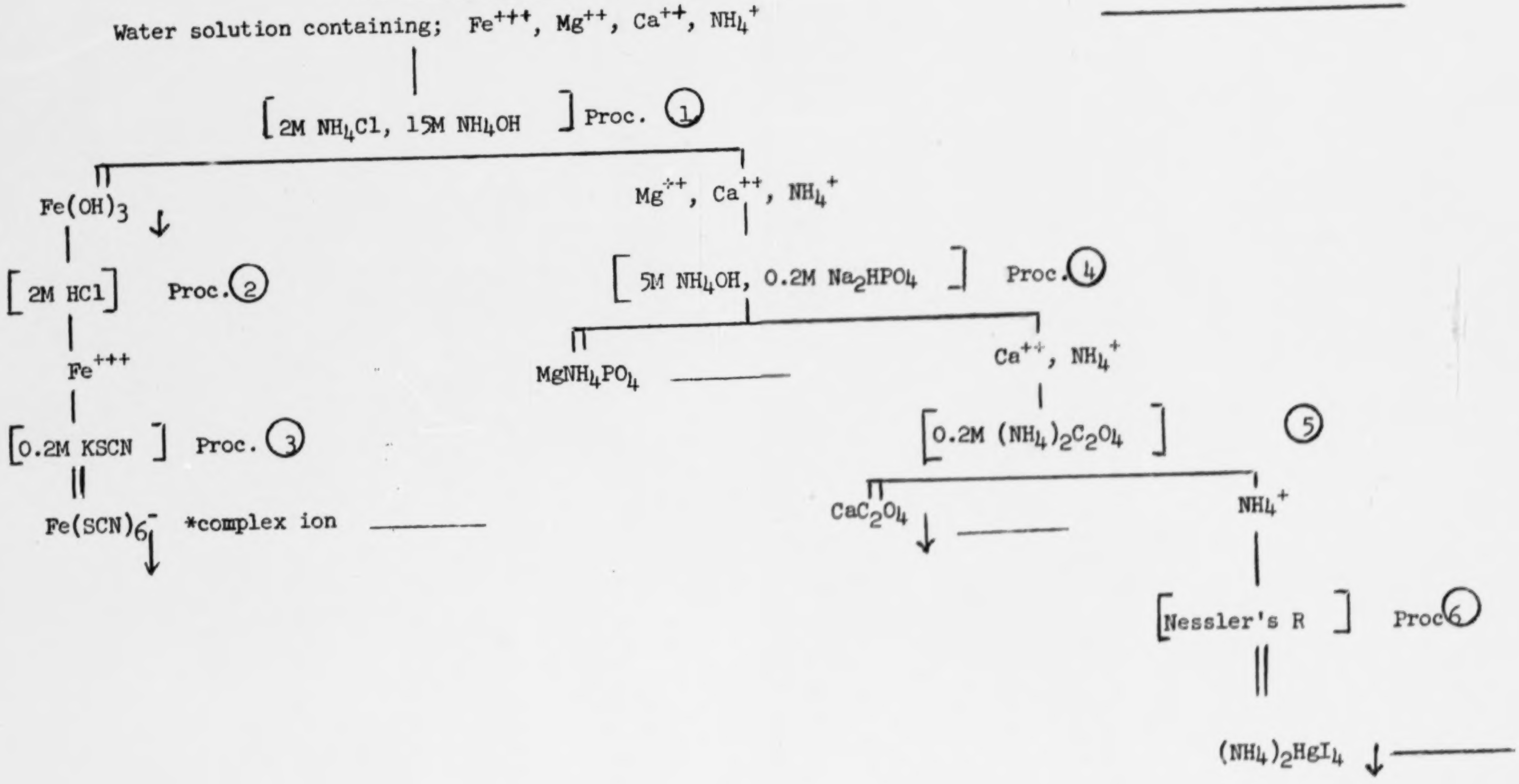
PROCEDURE # 13: Detection of the Cl^- ion.

Add 3 drops of 0.2M $AgNO_3$ to the decantate from Proc. 11. The formation of a white precipitate, $AgCl\downarrow$, confirms the presence of the Cl^- ion.

ANION ANALYSIS OF GROUND WATER


Water Solution Containing; HCO_3^-, CO_3^{--}, PO_4^{---}, SO_4^{--}, Cl^-
[HCl]
Proc. ⑦
Effervescence (?) ____
Water Solution Containing; HCO_3^-, CO_3^{--}, PO_4^{---}, SO_4^{--}, Cl^-
[Heat to Boiling]
Proc. ⑧
Ca, Mg, Fe^- CO_3 ↓ white
[HCl]
Proc. ⑨
H_2O + CO_2 ↑
PO_4^{---}, SO_4^{--}, Cl^-
[3M HNO_3; $(NH_4)_2MoO_4$]
Proc. ⑩
$(NH_4)_3PO_4$ $12MoO_3$ ↓ yellow
SO_4^{--}, Cl^-
[$Ba(NO_3)_2$]
Proc. ⑪
$BaSO_4$ ↓
[HCl]
Proc. ⑫
$BaSO_4$ ↓ White
Cl^-
[$AgNO_3$]
Proc. ⑬
AgCl ↓ white

CATION ANALYSIS OF GROUND WATER


Water solution containing; Fe^{+++}, Mg^{++}, Ca^{++}, NH_4^+
[2M NH_4Cl, 15M NH_4OH] Proc. ①
$Fe(OH)_3$ ↓
[2M HCl] Proc. ②
Fe^{+++}
[0.2M KSCN] Proc. ③
$Fe(SCN)_6^-$ ↓ *complex ion
Mg^{++}, Ca^{++}, NH_4^+
[5M NH_4OH, 0.2M Na_2HPO_4] Proc. ④
$MgNH_4PO_4$
Ca^{++}, NH_4^+
[0.2M $(NH_4)_2C_2O_4$] ⑤
CaC_2O_4 ↓
NH_4^+
[Nessler's R] Proc ⑥
$(NH_4)_2HgI_4$ ↓

Name ____________________
Science IIIB Hour ______
Date Due ________________

ANALYSIS OF GROUND WATER

REPORT SHEET

FIRST ANALYSIS:

Number of Sample __________ Date ____________

Cations Present:

_____ _____ _____ _____

Anions Present:

_____ _____ _____ _____

Grade ☐

"HARDNESS" IN GROUND WATER

All natural waters, except rain water, contain salts of calcium, magnesium, and to a lesser extent, iron plus small quantities of other salts peculiar to specific locations.

Limestone ($CaCO_3$), Magnesium carbonate ($MgCO_3$) and other carbonate salts (except sodium, potassium, and ammonium) are insoluble in water but soluble in dilute acid

Natural waters, in the process of reaching under ground pools, dissolve CO_2 (carbo dioxide) from the air and decaying vegetable matter in the soil. The carbon dioxi combines with the water to form a very weak solution of carbonic acid.

$$H_2O + CO_2 \longrightarrow H_2CO_3$$

The slightly acidic ground water slowly converts water insoluble carbonate salts to soluble bicarbonates.

$$CaCO_3 + 2H_2CO_3 \text{———} Ca^{++} + 2HCO_3^- + H_2O + CO_2\uparrow$$

$$MgCO_3 + 2H_2CO_3 \text{———} Mg^{++} + 2HCO_3^- + H_2O + CO_2\uparrow$$

Hardness in water is due to the presence of Ca^{++}, Mg^{++}, Fe^{+++}, and other heavy metallic ions. When ordinary soap ($NaC_{17}H_{35}COO$; sodium stearate) is added to water containing such heavy metal ions as, Ca^{++} or Mg^{++}, sudsing does not take place unless large quantities of soap are used; instead, a curd (precipitate) of insoluble Ca^{++} or Mg^{++} $(C_{17}H_{35}COO)_2$ is formed. No suds will form until enough soap has been added to remove all of the metal ions from the solution in the form of this stearate precipitate.

Another source of metal ions in water are the soluble sulfate salts. We recall that all sulfates except silver, mercury I, barium, and calcium are soluble in water. Ground water which comes in contact with Magnesium sulfate dissolves portions of the salt deposit and hence acquires Mg^{++} ions.

We are already familiar with the fact that water soluble bicarbonates are rather unstable and decompose with heat. Water which is "hard" because metal ions are present in conjunction with the bicarbonate is said to be "TEMPORARY" hard because the metal ions in solution may be removed by boiling the water. The effect of the boiling breaks the bicarbonate radical down to a carbonate which then combines with the metal ions present to form insoluble carbonate salts.

$$Ca^{++} + 2HCO_3^- + \text{heat} \longrightarrow CaCO_3\downarrow + H_2O + CO_2\uparrow$$

The sulfate radical (SO_4^{--}) is stable and is not affected by boiling. Water which is hard because of the presence of metal ions in conjunction with the sulfate radical is said to be "PERMANANT" hard because these metal ions cannot be removed except by an "ion-exchange" process.

The relative hardness of water depends upon the concentration of metal ions in solution. The greater the concentration of Ca^{++}, Mg^{++}, Fe^{+++} etc. the harder the water.

The concentration of metal ions in ground water, hence its "hardness", is generally expressed in units of Parts Per Million (PPM) or Grains Per Gallon of $CaCO_3$. This means, the parts by weight of $CaCO_3$ (or its equivalent) per million parts by weight of water.

Grains per gallon means, grains of $CaCO_3$ (or its equivalent) per gallon of water.
*(1 gram is equal to 15.4 grains.)

In view of the fact that hardness in water is due to the presence of metal ions, not $CaCO_3$, one may wonder why $CaCO_3$ is used as the basis for describing the hardnes of water. The reason for this unit is because the chief cause of hardness in water is the Ca^{++} ion in conjunction with the bicarbonate radical, and, historically, the first measure of the amount of hardness in water was made on the basis of the amount of $CaCO_3$ that could be precipitated by boiling the sample. Thus, if 20 grains of $CaCO_3$ could be precipitated from 1 million grains of water (by boiling the hardness of the water would be 20 PPM.

The great majority of fresh water supplies have hardness ranging from 10 to 500 parts per million, but some may run as high as 1800 ppm. In general, if the hardness is not greater than 120 ppm, the water is considered satisfactory for use, without softening, for municipal purposes.

One gallon of water weighs 58,823 grains. If one gallon of water was found to contain 1 grain of $CaCO_3$ (or its equivalent) the weight ratio would be 1 grain per 58,823 grains of water. By proportion it is possible to calculate the number of grains of $CaCO_3$ (or its equivalent) that this water sample would contain per million grains of water.

$$\frac{1 \text{ grain}}{58{,}823 \text{ grains water}} = \frac{\text{"X" grains}}{1{,}000{,}000 \text{ grains water}}$$

Solving for "X", we find that a hardness of 1 grain per gallon is the same as a hardness of 17 ppm.
*(7000 grains is equal to 1 pound)

Water is "softened" by treating the hard water with a chemical substance which supplies anions which will combine with the metal cations to form insoluble salts. This process, called an ion exchange, removes the metal ions from solution. There are a number of chemical substances which may be used for this purpose. Sodium tetraborate $Na_2B_4O_7$, called Borax, is such a compound and it is frequently used in homes to soften water. Products such as this are sold commercially as "washing powder" Boraxo is a common exp.

Patented ion exchangers such as zeolite and dowex have been developed for use in tank type water softeners. These compounds contain sodium cations which do not interfere with the cleansing action of soaps or cause the formation of curd. In the softening process heavy metal ions such as Ca^{++}, or Mg^{++}, or both, exchange places with the sodium ions.

$$Ca^{++} + \underset{\text{(Solid)}}{Na_2Z} \rightleftharpoons \underset{\text{(Solid)}}{CaZ} + 2Na^{+}$$

After a time all of the solid sodium zeolite is converted to Calcium or Magnesium zeolite. When this has happened the compound is unable to remove any more heavy metal ions and the compound must be "regenerated". In the regeneration cycle the zeolite compound is brought back to its original form by allowing a solution of common salt (NaCl) to flow through the material.

$$CaZ + 2Na^{+} \rightleftharpoons Ca^{++} + Na_2Z$$

Exercise

Name ______________________________

Science IIIB Hour _____

Date __________________________

HARD WATER

1. What is hard water?

2. What makes water hard?

3. Explain why ground water is able to dissolve carbonates, such as limestone and Magnesium carbonate, which are insoluble in water.

4. What is the difference between temporary and permanent hard water?

5. What kind of compounds make water temporary hard?

6. What determines the degree of hardness of water?

7. What compounds make water permanent hard?

8. In what units is the hardness of water measured?

9. What is meant by a grain?

10. Why was $CaCO_3$ selected as the basis for measuring the hardness of water?

11. Calculate the hardness of water, in ppm, that contains 20 grains/gallon.

12. Water which contains 400 parts of $CaCO_3$ per million parts of water contains ________________________ grains/gallon.

13. Explain the basic process of water softening.

14. What are washing powders?

15. Explain the "ion-exchange" that takes place in tank type softeners.

16. What happens to the salt that is poured into a water softener during the regeneration cycle?

Laboratory Investigation
(Individual Special Project)

EFFECTS OF WETTING AGENTS ON THE SURFACE TENSION OF WATER

INTRODUCTION:

A wetting agent is a substance that causes a liquid to spread more readily upon a solid surface and therefore, in many cases, to be absorbed more readily by the solid. It is a surface-active agent. Wetting agents are used in industry as scouring agents, dye assistants, softeners and delustering agents. A general use of such a material is as a detergent. A detergent is a substance which is capable of loosening, removing, and spreading out solid and liquid soils from a surface being cleaned. The term detergent is limited to those surface-active agents which loosen and hold clumped together soil and dirt so they can be washed away before they redeposit on the surface being cleaned.

PROBLEMS:

You may investigate one or more of the following problems:

1. Determine which of the wetting agents, contained in various detergents is most effective in reducing surface tension of water.
2. Determine which detergent of those available is most effective in reducing the surface tension of water.
3. Determine how the surface tension of water changes as the amount of wetting agent added is increased.

PROCEDURE:

Using the same apparatus as in Part II, add 1 drop of the wetting agent to the surface of the clear water. Be sure to use fresh water for each different wetting agent.

Your report should include the names of the wetting agents tested and the order of effectiveness. The answer to problem number 3 can best be represented graphically, plotting measured surface tensions along one axis and drops of wetting agent along the other axis.

Laboratory Problem

METHODS OF SOFTENING WATER

Hard water which contains heavy metal ions such as calcium, magnesium or iron in combination with the bicarbonate radial (HCO_3) is said to be "temporary hard". The reason for this is that water can be softened by simply boiling the water. The effect of the high temperature causes the rather unstable bicarbonate radical to break down.

Metal ions which, in combination with the sulfate or carbonate radical, make water "permanently hard", may be removed by a process of ion exchange. In this process the heavy metal ions are replaced by sodium ions. Sodium salts which are added to the water for this purpose are called "washing powders". Three sodium salts, commonly used in commercial washing powders are:

sodium biphosphate	Na_2HPO_4
sodium tetraborate	$Na_2B_4O_7$
sodium bicarbonate	$NaHCO_3$

When any of these salts are put into solution with hard water the following ion exchange takes place:

$$CaSO_4 + Na_2B_4O_7 \rightarrow CaB_4O_7 + Na_2SO_4$$

The heavy calcium metal is removed from the solution as a precipitate. The sodium sulfate is soluble.

In this experiment we shall attempt to determine what percentage of the hardness of a water sample is due to chemical salts which make the water temporary hard and those which make the water permanent hard. Also, which of the chemical salts listed above make the most effective water softener.

PROCEDURE:

A. Boil a sample of tap water for two minutes. Take 10-ml of the boiled water and determine its hardness, in ppm, by means of a standard soap test. Assume that the original hardness of the water is _____ ppm, and that the standard soap solution produces _____ ml of suds in distilled water.

B. Three members of the lab. will prepare three different 250-ml of a "washing powder" solutions by dissolving 1-g. of the salt to be tested as a washing powder to 250-ml of tap water.

Take 10-ml of each solution and determine its hardness by means of the standardized soap test.

DATA:

A.

WATER	ml OF SUDS	HARDNESS ppm
BEFORE BOILING		
AFTER BOILING		

B.

SALT ADDED	ml OF SUDS	HARDNESS ppm
Na_2HPO_4		
$Na_2B_4O_7$		
$NaHCO_3$		

RESULTS:

A. Hardness of the water sample after boiling:______________________________

% of hardness due to the presence of bicarbonate salts__________________

B. Relative effectiveness of the chemical water softeners:

_____ Na_2HPO_4

_____ $Na_2B_4O_7$

_____ $NaHCO_3$

QUESTIONS:

1. What kind of chemical compounds make water:

   a. permanent hard

   b. temporary hard

2. Why do all washing powders contain salts which have SODIUM as the only metal ion present?

3. Calculate the hardness of a water sample, in grains/gallon, which contains 0.2 grams of mineral matter in two quarts of water. One quart of water weighs 2 lbs.

4. Calculate the hardness of the above water sample in ppm.

EXPANSION OF THE AVAILABLE WATER SUPPLY

I. Improved Management of Existing Supplies

A. Transporting of supply

B. Conservation practices

II. Development of "New" Supplies

A. From atmosphere

B. From the ocean

1. Desalination

2. Polar ice

I. Historical uses of water

Ancient civilizations--Rome, Greece, Egyptian, Mesopotamian

II. Importance of water living systems and industry

III. Structure of water molecule

Placement of oxygen orbitals

Distribution of charge

105° angle

polar bond

hydrogen bond

IV. Properties of water (Physical and chemical)

Common

Unusual

V. Solutions and suspensions

VI. The hydrological cycle and distribution of water

VII. Manageable water supply

VIII. Societies requirements

IX. Water pollution

Biological and chemical

Industrial

Domestic

Agricultural

X. Methods of purification natural and technilogical

XI. Expansion of water supply

SOILS

Soils - Important Part of an Ecosystem

Problems in the Utilization of Soils

Utilization of Natural Resources

SOILS

INTRODUCTION:

The world has its problems. We are considering a few of them: the pollution of our environment, the reckless wasting of our resources and the increasing world population. All of these problems are interrelated and cannot be thoroughly resolved in isolation.

For example, the problem of enough food to feed all is related to maintaining a supply for the demand of an increasing number of organisms on the ecosystem known as the earth. The soil is an important ingredient in the solution to the problem. The soil is itself an amazingly complex ecosystem whose shaky balance must be maintained in order that soil be utilized to its greatest advantage. The interrelationships in the soil and between the soil and the organisms on it are delicately balanced. When the balance is kept the soil is vital and the products bountiful. What happens? Man, in his extreme ignorance or selfish and greedy disdain, tramples, plows, and trods his way through this balanced system and soon causes corruption. The plant cover is destroyed; the soil network is destroyed and the results are soil erosion, leaching and the accumulation of sand and silt in water and lakes. Catastrophes occur: floods, dust storms, and finally the inability for growth.

We, in this country, were beginning to understand that a good agricultural economy is the base upon which a thriving industrial economy will continue to grow. But we seem to have lost sight of the big picture and try to make the fastest "buck", the cheapest way we know how. The land suffers; the water suffers; we suffer. Perhaps not directly because we still get our steaks, our fruit, our vegetables, and our water, but the cost is higher. The price is greater than we realize - a disruption in the balance of nature, which cannot be healed or reinstated as quickly as we have been attacking it. We have to stop and think and realize what the full consequences of our actions are. We must, in fact, all become ecologists at heart.

Utilization of Natural Resources

SOILS

Resource Material:

Required Reading:	Soils, Yearbook of Agriculture, 1957, pages 1-49, 631.4 Un5 Soil, Scientific American Reprint #821

QUESTIONS FOR CONSIDERATION:

1. What is soil?

2. What are the physical properties of soils?

3. What makes a soil fertile?

Utilization of Natural Resources

SOILS - IMPORTANT PART OF AN ECOSYSTEM

I. Soils

A. Definition

B. Formation of Soils

C. Factors Effecting the Formation of Soils

1. climate

2. living organisms

3. parent rock

4. topography

5. time

II. Classifications of Soils

  A. Major Classifications

    1. Local

    2. Regional

    3. Groups

    4. Belts

      a. mountainous

      b. tundra

      c. desertic

      d. latasolic

      e. podzolic

      f. chernozemic

Utilization of Natural Resources

FILM STRIP - SOILS

1. Identify the layers found in the regolith of the earth's crust.

2. Name the methods by which soil is formed.
   a.
   b.
   c.

3. What factors cause soil to decay?

4. What determines the mineral content of soils?

5. What determines the type of soil that is formed?

6. What function do bacteria have in the development of soil?

7. How do chemicals necessary for plant growth get into the soil?

8. How do soluble nitrogen compounds get into the soil?

9. Name the basic soil types.

10. What are the characteristics of each soil type?

11. What is loam?

CLASSIFICATION OF SOILS

Soil particles vary greatly in size. The largest particles settle quickly in water solution. Fine particles settle slowly, while some particles are so small that they remain suspended in solution indefinitely.

Soil scientists classify soil particles into three group: sand, silt, and clay.

clay = diameter less than .002 mm.
silt = .002 to .05 mm. in diameter
sand = .05 to 2.0 mm. in diameter

Particles larger than 2.0 mm. are called gravelstones.

Most soils, as found in nature, contain a mixture of sand, silt, and clay in different proportions. The size of soil particles is important. The amount of open space between the particles has much to do with the ease in which water moves through a soil and with the ability of the soil to hold water. Too much clay, in proportion to silt and sand, causes a soil to take in water very slowly. Such a soil gives up its water to plants and is stickly when wet.

Loam and silt loam refer to soils that have a favorable proportion of sand, silt, and clay. Loams are classified as follows:

sandy loam - no more than 50% sand
no more than 27% clay
no more than 23% silt plus humus
A soil that contains more than 50% sand is a sandy soil.

clay loam - no more than 50% clay
no more than 27% sand
no more than 23% silt plus humus
A soil that contains more than 50% clay is classified as clay soil.

silt loam - not less than 50% silt
a. brown silt - not less than 50% silt, at least 27% sand
b. black silt - not less than 50% silt, at least 27% clay

Laboratory Investigation

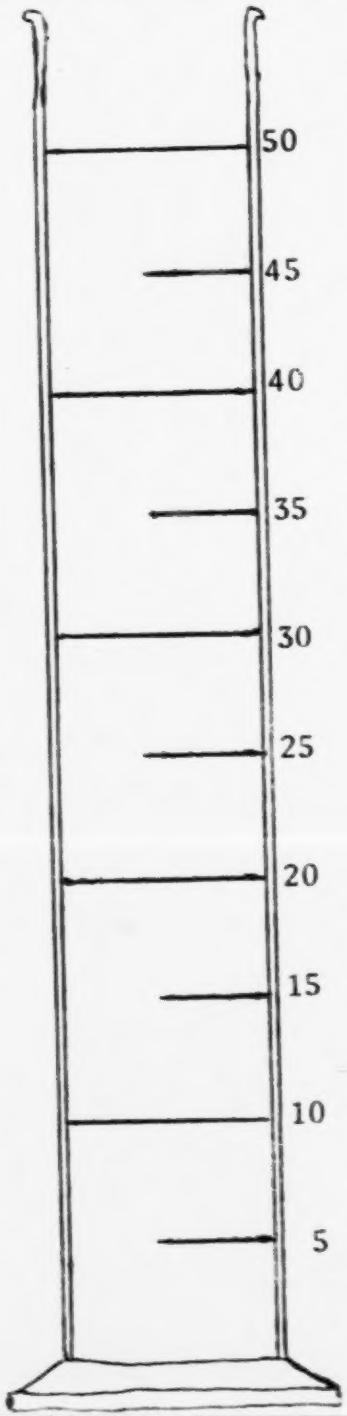
CLASSIFICATION OF SOILS

PURPOSE:

The purpose of this experiment is to determine the proper classification of the soil sample by means of a sedimentation test and analyze this sample for the "Big Three".

PROCEDURE:

Add about 30 ml. of loosely packed soil to a 50 ml. graduate. Be careful to mix the soil sample thoroughly before placing the sample in the graduate. Fill the graduate to within an inch or two of the top with water. Cover the end of the graduate with the palm of your hand and shake the mixture for several minutes, or until all of the soil particles are in suspension. Add more water if necessary. Set the graduate on the laboratory table and allow the particles to settle. After the particles have settled, fill in the drawing at the left indicating the exact amounts of each soil type found in the sample. Read the level at the top of the clay and determine the percent of the various soil particles using the total volume of the soil as the basis for calculating the percentage composition. Label each layer in the diagram and indicate the percent composition. Determine the proper classification for the soil sample.



QUESTIONS:

1. What are the characteristics of clay soil?
2. Why is size of soil particles important?
3. What are the characteristics of sandy soils?
4. What are the characteristics of a loam soil?

CLASSIFICATION ______________________

III. Properties of Soils

A. Determining Factors

B. Physical

1. Texture

2. surface area/unit mass

3. Density

4. Porosity

5. Longevity

6. Thermal Conductivity

7. Cohesive Strength

C. Chemical

1. Basis in Particle Size

2. Acidity

The material on pages 50-54 may be found

TITLE Life In The Soil BSCS Lab Block

AUTHOR Biological Sciences Curriculum Study David Pramer

PUBLISHER D. C. Heath & Company

PAGE NO. 2-5

PROBLEMS IN THE UTILIZATION OF SOILS

I. Fertility of Soils

A. Determination of Fertility

B. Minerals Effecting Fertility

1. Indirectly Taken From Air and Water
    - a.
    - b.
    - c.
    - d.
2. Elements Taken Directly From the Soil

a.	d.
b.	e.
c.	f.

3. Trace Elements

a.	d.
b.	e.
c.	f.

4. The Most Critical - The Big Three

II. Fertility and Plant Growth

57

PREPARATION OF SOIL EXTRACT FOR TEST FOR NITRATE NITROGEN, PHOSPHOROUS, POTASSIUM

The following procedure for preparing the soil extract applies to the tests for all of the elements and radicals listed above. A single soil extract, using the Universal Extracting Solution, is used for all of the tests.

PROCEDURE:

1. Fill the multiple extraction tube to the upper mark, 14 cc., with the universal extracting solution.
2. Add two measures of the soil sample to be tested. To measure the soil, fill the large depression of the cylinder-shaped porcelain soil measure heaping full with soil and strike off level with a straight edged tool.
3. Stopper the tube and shake for exactly one minute.
4. Place a piece of filter paper in a funnel tube and filter the contents into a clean test tbue. Stopper the tube tightly and label it. The solution, thus prepared, contains the elements of the soil which may be identified during successive class periods. Mark the tube and set it aside.

PREPARATION OF THE SOIL SAMPLES:

When representative samples have been collected from different areas of the land to be tested the soils are quite damp and must be air dried. For this operation each sample should be spread out on a paper that has been marked according to the soil sample. Lumps should be broken with a spatula and the soil left to dry at room temperature. When the soil is sufficiently dry to sift easily through the fingers, it should be sifted through a wire screen about the size of ordinary window screen. This removes pebbles and foreign matter and will yield a fine soil sample ready for preparation of the soil extracts and the tests for pH. The soil sample should be placed in a marked container and stored in a warm dry place.

POTASSIUM SOIL TEST

This test is used to determine the amount of replaceable and water soluble potassium in the soil. It is important that the temperature of the test sample and the Potassium Reagent C be kept within the range of 68 to 80 degrees F. during this test in order to ensure complete precipitation of the potassium. If the temperature of the air is above 80 degrees the vial containing the solutions should be cooled by placing it in water during the mixing operations.

PROCEDURE:

1. A clean potassium "A" tube is filled to the lower mark with soil extract.
2. Add one reagent B tablet to the tube and dissolve it in the soil extract solution.
3. Add reagent C to bring the level of solution to the upper mark on the tube. Allow the reagent to run slowly down the side of the tube. Mix by twirling the tube between the fingers. The formation of a precipitate indicates the presence of potassium, the amount depends upon the quantity of precipitate.
4. Place a potassium "B" tube in the clip in the reading stand. The stand should be facing a window. The tube should be one-half inch above the plate.
5. By means of a dropping pipette, add the test sample slowly, allowing it to run down the sides of the tube while observing the black line through the solution. Continue until the line just disappears.
6. The height of the column of the test sample is measured against the potassium scale on the tube. The potassium content is read directly, in pounds per acre, from the tube. If the potassium content exceeds the highest value indicated on the scale the original filtrate should be diluted with an equal volume of Universal Extracting Solution. The potassium "C" tube is used to make this dilution. Pour the test sample into the Potash "C" tube filling it to the lower mark. Add Universal Extracting Solution to bring the level to the upper mark. Transfer the solution to a clean Potash "A" tube, filling it to the level of the lower mark. The test is then repeated (steps 2 through 6) and the reading multiplied by two.

PRECAUTIONS:

The bottles containing the chemicals should be kept tightly stoppered to prevent loss and contamination. It is absolutely essential that the chemicals be used in exactly the amounts and in the order directed.

After each use the apparatus must be thoroughly cleaned and dried before returning to the storage area.

The reading on the tube is given in terms of pounds of potassium (K) per acre. To obtain results in terms of K_2O (potash) multiply the K reading by 1.2

RESULTS:

Amount of Potassium in Sample Tested

__________ pounds per acre __________ pounds per 1000square feet

Amount of Potash (K_2O) in Sample Tested

__________ pounds per acre __________ pounds per 1000 square feet

NITRATE NITROGEN SOIL TEST

This test was devised for the purpose of determining whether or not a soil contains sufficient nitrate nitrogen for good crop growth. Since the abundance of nitrate nitrogen in the soil is quite variable, depending on the stage of growth of the crop, the temperature of the soil, the occurance of leaching, it is necessary to test soils frequently for their nitrate content.

PROCEDURE:

1. Transfer one drop of soil extract to one of the depressions on the spot plate. Use a sampling pipette for handling the extract.
2. Add four drops of the Nitrate test solution and stir the mixture with a glass rod.
3. After two minutes, the resulting blue color is compared with the Nitrate Color Chart. If the deepest shade of blue shown on the chart is produced, the test should be repeated.

   Transfer one drop of the soil extract to another depression in the spot plate and dilute it with four drops of Universal Extracting Solution, and then transfer one drop of the diluted extract to another depression in the spot plate and test as before. The amount of nitrate nitrogen corresponding to the shade of blue thus produced must be multiplied by 5 to obtain the amount of nitrate nitrogen contained in the soil.

   If the color obtained is not a direct match for a specific shade on the color chart estimate the value on the basis of comapariosn between two shades which appear on either side.

RESULTS:

Amount of Nitrate Nitrogen in the Sample Tested:

__________ lbs. per acre

__________ lbs. per 1000 square feet

General Evaluation:

very high	high	medium high	medium	medium low	low	very low
○	○	○	○	○	○	○

PHOSPHORUS SOIL TEST

It is extremely important to test soils in order to find out whether or not they contain sufficient readily available phosphorus for good plant growth. By means of the following test it is easy to determine available phosphorus in soil. The results are reported in pounds of phosphorus per acre.

PROCEDURE:

1. The phosphorus "B" tube is filled to the mark with the soil extract.
2. Add six drops of reagent 2 and shake thoroughly.
3. Add one tablet of reagent 3 and shake until dissolved.
4. Compare immediately with the phosphorus color chart.

   In making the comparison hold the vial over the white portion of the chart, about one inch from the paper, slide it back and forth until the color is found which matches most closely that in the vial.

   For making these readings it is best to face a window. If artifical light is used the chart and vial should be held about one foot from the light. Do not use a ceiling light for this work. Do not allow the solution to stand for more than ten minutes before making the color comparison.

PRECAUTIONS:

This test is so extremely sensitive that it is necessary to take special precautions to keep out all contamination. Be careful that the solution never comes in contact with the hands during any part of the operation.

RESULTS:

Amount of Phosphorus in the Sample Tested

__________ pounds per acre

__________ pounds per 1000 square feet

General Evaluation

very high	high	medium high	medium	medium low	low	very low
○	○	○	○	○	○	○

RELATIVE NITROGEN, PHOSPHORUS, AND POTASSIUM REQUIREMENTS FOR COMMON CROPS AND PLANTS

VH = very high, H = high, M = medium, L = low, L* nitrogen supplied by legumes

Type of Plant	Nitrogen	Phosphorus	Potassium
asparagus	VH	H	VH
beans	L	M	M
beets, early	VH	VH	VH
blueberries	L	L	L
bluegrass (Kentucky)	M	M	L
brussels sprouts	H	H	H
cabbage	H	H	H
carrots, early	H	H	H
clover	L*	M	M
corn, sweet - early	H	H	H
cucumbers	H	H	H
deciduous plants	M	L	L
deciduous shrubs	M	M	L
deciduous trees	M	L	L
evergreens	L	L	L
flowers, annuals	H	H	H
flowers, perennials and bulbs	M	M	M
grasses, mixed	M	L	L
lawns	M	M	L
lettuce, leaf	H	VH	VH
lettuce, head	VH	VH	VH
muskmelons	H	H	H
onions	H	H	H
pears	M	L	L
peas, early	M	H	H
peas, field	L*	M	M
potatoes, early	VH	VH	VH
pumpkins	M	M	M
radishes	H	VH	VH
raspberries	L	L	L
rhubarb	H	H	H
spinach	VH	VH	VH
squash	H	H	H
strawberries	M	M	L
tomatoes, early	M	H	H
turnips	L	H	M
watermelons	M	M	M

Soils used for garden crops should contain at least:

180 pounds of P_2O_5 (75 lb. P) per acre
200 pounds of K_2O (167 lb. K) per acre - water soluable and available
50 pounds of nitrogen per acre

On the basis of these figures calculate the amount of each of the "Big Three" elements that you would need to add to your soil in pounds per 1000 feet squared.

	now available	to be added
nitrogen		
phosphorus		
potassium		

SOIL ACIDITY TEST - pH

The three compartment porcelain block is placed so that the larger, divided depressions are uppermost and away from the operator. This position allows the indicator that is added to the upper side of the porcelain wall of the larger depression to pass through the small openings in the wall, through the soil sample on the lower side of the wall, and down the channel to the smaller depression, where the comparison is made.

PROCEDURE:

1. A small portion of the soil sample is placed in the lower part of the larger depression of the compartment, so as to fill completely the section between the perforated wall and the channel. The soil should not be pressed down tightly, and in no case should it be touched by the hand.
2. By means of the pipette, Bromthymol Blue Indicator is added slowly, drop by drop, to the upper portion of the larger depression of the first compartment, above the perforated partition, until the soil is completely saturated. The liquid will begin to appear at the lower edge of the soil mass. This part of the process should be watched closely, so that an excess of the indicator solution does not cause flooding. After completing the test wash the procelain block with tap water, rinse in distilled water and dry the block.
3. As soon as the indicator solution appears at the lower edge of the soil mass, it is drawn down into the lower depression by means of a glass rod. If it is allowed to run down the channel, too thick a layer will be obtained in the small depression, so that it will be difficult to obtain a match with the color chart.
4. The solution in the lower depression is compared with the Bromthymol Blue Color Chart. This comparison must be made immediately. If a color match is obtained the pH value is read directly from the chart. If the color obtained with the Bromthymol Blue is yellower than the 6.0 block on the chart, the soil is acid and the soil sample should be retested following steps 1-4, except that Chlorphenol Red is used in place of the Bromthymol Blue. If no color match is obtained with the Chlorphenol Red, repeat the test on another soil sample using Bromcresol Green. If the color obtained with the Bromthymol Blue is bluer than the 7.6 block on the Bromthymol Blue Chart, the soil is alkaline, and the Phenol Red Indicator is used to test the sample. If, for any of the reagent solutions, the indicator dye is absorbed by the soil sample, the solution passing through the soil will be colorless. If this happens add one drop of the appropriate indicator directly to the clear solution and make the color comparison in the usual manner.

RESULTS:

pH of the Soil Sample ________

INTERPRETATION OF RESULTS:

To simplify the classification of plants according to their soil reaction preferences, they have been divided into three main groups. Those plants prefering soils whose reaction is within the "neutral zone" (6.0-8.0) are placed in group A. Plants preferring slightly acid soil (5.0-6.0) are placed in group B. Plants that thrive on acid soils between 4.0 and 5.0 are placed in group C.

The following tables are used to calculate the amounts of hydrated lime or aluminum sulfate (alum) needed to correct any pH condition of the soil for each specific plant group.

GROUP A PLANTS (pH 6.0-8.0)

pH Reading	Average Amount of Powdered Limestone ($CaCO_3$) Needed For Different Acid Soils in Pounds Per Square Yard			
	Sandy Soil	Sandy Loam	Loam	Silt And Clay Loam
4	1/2	1	1½	2
5	1/4	1/2	1	1½
6	1/8	1/4	1/4	1/2
7	none	none	none	none
8	none	none	none	none

GROUP B PLANTS (pH 5.0-6.0)

pH Reading	Average Amounts of Hydrated Lime Needed For Different Soils in Pounds Per Square Yard			
	Sandy Soil	Sandy Loam	Loam	Silt and Clay Loam
4	1/4	1/2	1	1½
5	1/8	1/4	1/4	1/2
6	none	none	none	none
	*Average Alum Needed For Alkaline Soils in Pounds Per Square Yard			
7	1/2	1	1	1½
8	1	2	2	3

GROUP C PLANTS (pH 4.0-5.0)

pH Reading	Average Amounts of Hydrated Lime Needed For Different Soils in Pounds Per Square Yard			
	Sandy Soil	Sandy Loam	Loam	Silt and Clay Loam
4	1/8	1/4	1/4	1/2
5	none	none	none	none
	*Average Alum Needed For Different Alkaline Soils - Lbs./Sq.Yd.			
6	1/2	1	1	1½
7	1	1½	2	3
8	2	3	4	6

*In small gardens it is most convenient to apply the alum in solution. Dissolve the alum in water at the rate of one-half pound per gallon and apply as required.

PLANT NUTRIENTS AND PLANT GROWTH

"The Big Three" - The Critical Elements

A. NITROGEN: The nitrogen of the soil exists almost entirely in the organic matter. In this form the nitrogen is not available for use by the plants directly, but must first be transformed by soil bacteria (oxidation) to nitrates which are soluble in water and which may then be absorbed by the plant roots.

The nitrates formed by "nitrogen fixing bacteria" are the by-products of their own feeding activity on the organic matter in the soils. Soils ordinarily contain in the neighborhood of 0.1% of nitrogen. Only a small percentage of this amount is available as soluble nitrates. Aside from continual cropping, the leaching action of water carries much available nitrogen deep into the soil, below the root levels. It is thus apparent that the supply of nitrogen in soils is small when compared to the need of plants. Sandy soils in particular are low in nitrogen due to rapid leaching and decomposition of organic matter.

1. The Effect of Nitrogen on Plant Growth - Of the "Big Three", nitrogen has the quickest and most pronounced effect on plant growth.

   a.

   b.

   c.

   d.

   e.

2. Characteristics of Insufficient Nitrogen

   a.

   b.

   c.

3. Effects of over abundance of Nitrogen - The only one of the "Big Three" which has a harmful effect on plants if added in excess.

   a.

   b.

   c.

   d.

   e.

   f.

4. Crops which require large amounts of Nitrogen

   a.

   b.

   c.

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B. PHOSPHOROUS: Life, either plant or animal, cannnot exist without phosphorous! The soil is the source of this element. A lack of phosphorous not only retards growth but also lowers the "tone" and vigor of both plants and animals.

Animals secure their phosphorous indirectly from plant foods. Plants secure their phosphorous directly from the soil.
The plowed layer of soil on an acre of ordinary loam soil weighs about two million pounds. A normal loam would contain about 0.05% phosphorous which would be 1000 pounds per acre. An acre of corn removes about 25 pounds of phosphorous so after about 40 crops of corn a soil would be about exhausted as far as phosphorous goes. Thus it is easy to see that the supply of phosphorous in the soil can be quickly exhausted unless some provision for its return is made.

1. Functions of Phosphorous. Why phosphorous is essential for life. The following occur only in the presence of phosphorous.

   a.

   b.

   c.

   d.

   e.

   f.

   The following are improved by phosphorous content.

   g.

   h.

   i.

   j.

   k.

2. Characteristics of a lack of Phosphorous

   a.

   b.

3. Minimum percent of Phosphorous, by Weight, for General Cropping.

   a. sandy and clay loams

   b. sandy soils

   c. for garden crops

C. POTASSIUM (COMMONLY CALLED POTASH): Soils contain large amounts of potassium but most of it is in a non-usable, nonsoluble form. Soil acidity is an important consideration for the utilization of potassium for the presence of calcium seems to be necessary for the growing plant to take up potassium. Soils that are very acid are deficient in calcium. In such cases, the plant cannot utilize potassium even though it may be present in large amount in a soluble form.

Soils having an excess of calcium may also show symptoms of a lack of potassium since the plant is likely to take up calcium in preference to potassium.

A pH between 5.0 and 7.0 represents the limits for effective utilization of potassium.

1. Function of Potassium.

   a.

   b.

   c.

   d.

   e.

2. Effects of Insufficient Potassium.

   a.

   b.

   c.

3. Potassium does not enter into chemical combination in plant structure.

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Laboratory Investigation

PLANT NUTRIENTS AND PLANT GROWTH

PURPOSE:

To study the effect that different combinations of soils and plant nutrients have on plant growth.

PROCEDURE:

Each student will be expected to work with at least one soil type and/or plant nutrient to determine the factors involved in permitting lush growths.

Problems to consider:

1. Which factors are important in plant growth and how will these be tested?
2. How will a luxuriant or good growth of the plant be measured as opposed to a poor one?
3. How will the individual and class data be handled?
4. How will the final results be reported?

The material on pages 68-74 may be found

TITLE Life In The Soil BSCS Lab Block

AUTHOR Biological Sciences Curriculum Study David Pramer

PUBLISHER D. C. Heath & Company

PAGE NO. 51-54

Problems of Coexistence with the Physical Environment

Utilization of Natural Resources

MINERALS

Characteristics of a Resource

Distribution

Supply and Demand

MINERALS

Resource Material

Required Reading:	Expanding Populations in a Shrinking World, Bates Public Affairs Pamphlet #4, pages 17-20.
	Minerals, Scientific American Reprint, September 1963.
Recommended Reading:	The Earth, Life Nature Library, pages 91-103.
For Listening:	"Minerals for a Teeming World", Just

QUESTIONS FOR CONSIDERATION:

1. What is a resource?

2. Distinguish between renewable and non-renewable mineral resources.

3. How can we extend our natural resources?

4. How is power (energy) related to mineral resources?

5. What new technological advances in mineral discovery and utilization are being considered?

6. What are some factors that will help to determine the future supply of and demand for raw materials?

MINERALS

I. Mineral Resources

A. Minerals

. . . naturally occuring organic and inorganic compounds (we will be concerned primarily with non-fuel minerals at this time)

B. Rocks vs. Minerals

	Rocks	Minerals
composition		
shape		
size		
grouping		

C. Historical Discovery and Use of Minerals

II. Role of Minerals in Contemporary World Technology and Economics

A. An Industrial Society's Dependence on Minerals

1. The United States

2. International Demands

B. Energy, the Limiting Factor

III. Mineral Resources and the Future

A. Problems of Supply and Demand

B. Technological Answers to Mineral Depletion

1. Exploration

2. Substitution

3. Conservation

4. Utilization

5. Higher Prices to Eliminate Waste

Minerals

Laboratory Investigation

METALLURGY

INTRODUCTION

Metallurgy is the science of taking metals from their ores, refining them, and preparing them for use. An ore is a mineral or rock containing minerals that contains a metal (or metals) in sufficient quantity to be worthwhile economically to refine. Some metals do not require much processing before being refined; so called free metals or native metals are not combined chemically with other elements or compounds and can usually be separated by physical means from their rock mixtures. Gold, silver and platinum are of this type. Most metals, however, are chemically combined with other elements and their ores require energy expenditures of a chemical nature before obtaining the desired metal. The industrial process of obtaining metals from their ores is usually called smelting.

PURPOSE

To process an ore and obtain the metal in a refined state.

MATERIALS

lead carbonate $PbCO_3$

porcelain crucible

mortar and pestle

powdered charcoal

PROCEDURE

1. Weigh out 20 grams of $PbCO_3$ and grind it to a fine powder in the mortar.
2. Transfer the $PbCO_3$ to your porcelain crucible and heat (moderately to begin with and then up to maximum intensity) until all of the material has changed color. Complete the equation:

   $$PbCO_3 + O_2 \xrightarrow{\Delta}$$
3. Weigh out 2 grams of fine charcoal. Place the charcoal with the lead oxide from the cooled crucible in a clean mortar and grind to a powder. Transfer this mixture to a clean crucible and sprinkle 1 gram of charcoal powder on top of the mixture. Cover the crucible and apply intense heat for 15 minutes. Remove the cover and gently stir the contents (have your lab partner hold the crucible with tongs) to allow the metal drops to run together. Recover and continue heating for 3 more minutes. Remove from heat and allow to cool (about 10 minutes).
4. Remove the cover and slowly add 3-ml of water, one drop at a time.
5. Transfer the material to a beaker and wash the metal with your wash bottle to remove the carbon.
6. Weigh the lead metal. ________ grams

Laboratory Experiment

Name ________________
Science IIIB Hour ______
Date Due ______________

METALLURGY

INTERPRETATION OF RESULTS:

Data: Weight of $PbCO_3$ __________
Weight of pure Pb recovered __________

1. Theoretically how much lead should 30 grams of $PbCO_3$ yield?

____

2. Atomic wieght of Pb = 207, C = 12, O = 16. On the basis of these atomic weights, what percentage of the weight of $PbCO_3$ is due to the weight of the lead?

____

What was your percentage of recovery?

____

2. Write the equation which describes the reaction between lead oxide, PbO, and the charcoal, C.

3. How could the lead obtained in this smelting process be further purified?

4. Step #3 in the procedure was a smelting process in which the metal in the ore was reduced (recall that reduction is a result of electrons being gained). What supplied the electrons which caused the lead oxide to be reduced to lead?

5. In any reaction where reduction, (gain of electrons), takes place there must also be oxidation (loss of electrons). What element in this reaction was oxidized?

PROBLEMS OF COEXISTENCE WITH OTHER ORGANISMS

Parasitism, Predation, Symbiosis, Commensalism

Health and Disease

Agriculture

Fish and Wildlife

MAN'S RELATIONS WITH OTHER ORGANISMS

If we go back and try to imagine the place of prehistoric man in the biological community we see him primarily as a predator. Early man's place in the community was comparable with that of the social canines, such as the wolf. Man probably became a fairly effective predator quite early because he successfully adopted tool using and developed a cohesive social organization. He probably was never a predator exclusively, but ate fruits, nuts and tubers as additional foods. At times the tables would be turned, and man would be prey for other predators such as lions and crocodiles, although his group habits must have given him a large measure of protection. His tribal or family groups, however, would not protect him from parasitism, and some of the human parasites, especially the intestinal types like malarial Plasmodia, and body lice, show evidence of having evolved right along with man.

Early man, then, was predator, prey, and host for parasites, and also a sort of general scrounger or collector of fruits, nuts and insect grubs. It is evident from cave drawings, for example, that he quite early learned to rob bees' nests of honey. This general type of activity is described as "collecting".

With the development of tool making and using man's collecting activities extended greatly. We have a record of his making stone tools, and to some degree of his use of bones, but he must at the same time have used wood in many ways, and learned the special properties of many kinds of plants. If we can judge from present food gathering tribes (for example, the Austrialian bushmen) Stone Age man must have acquired an extraordinarily detailed knowledge of the utility of the plants and animals among which he lived - as sources of food, fiber, medicine, poison and paint.

These relationships multiplied as man learned to interfere more drastically with the biotic community. One of the first things he must have done was to build shelters. We talk about "cave men" and man may have been primarily a cave animal in a few situations, during glacial times in Europe, for instance, but mostly we associate him with caves because these are readily preserved and found. Men living in the open have probably always far outnumbered the cave dwellers. And the men in the open surely learned to construct shelters - even chimpanzees make nests.

If you build even a crude sort of shelter in wild country, a wide variety of animals will quickly move in on you to share your shelter - scorpions, cockroaches, lizards, mice. As soon as man starts making very extensive systems of shelters, a new process is involved - the clearing of the land. In clearing, man creates what we may call an "open habitat", which is a rare situation in nature. The special open habitat is immediately invaded by a series of plants, with their associated animals, that are uncommon or unknown in the usual stable and closed biological community. These are the plants we will call weeds. Weeds seem to us common and tough, but in the parts of the world that man has not yet greatly disturbed, like the northern coniferous forest or the rain forest of the upper Amazon, these weeds are extremely scarce. Weeds then are really "opportunists".

We come now to the animals and plants that man deliberately propagates and encourages - these we can call "cultigens". These are a late development but now the most important of man's biological relationships. Perhaps we should make a distinction between cultigens and pets. Many primitive peoples kept tamed animals around their settlements. Such animals are not always maintained from generation to generation like "cultigens" but are captured individually from the wild. Our current idea of a pet, of course, is an animal kept for amusement or because of affection. Biologically it would be more useful to distinguish between pets and cultigens on the basis of whether or not they have been modified through their association with man. By this criterion, dogs, having been modified by man, are "cultigens" instead of "pets". Some organisms are now in transition from "pets" to "cultigens". The Australian budgerigars or parakeets that breed so readily in captivity are one example. But while this may be the origin of such cultigens as common flowers it hardly explains important crops or animals.

Man's relationships with animals and plants can thus be separated into a number of biological categories of organisms: his prey, his predators, his parasites, his object of collection, the opportunists, the cultigens, and the pets. A similar classification in cultural terms would be quite different, involving magic and totem, food, medicine, ornaments, and the like. Our present interest, however, is to examine man's relationships with other organisms.

PREDATION & SYMBIOTIC RELATIONSHIPS

Resource Materials

Required Readings: BSCS Green - pp 83-89, 241-242

Recommended Reading: The Forest & the Sea, Bates

The Web of Life, John H. Storer

Rats, Lice & History, Hans Zinsser

"A Paleo Indian Bison Kill" - J.B. Wheat
Scientific American, Jan. 1967.

MAIN IDEA:

In the complex web of food relationships within the biological community animals not only eat, but in turn are eaten. If we ignore for the present decomposers and scavengers (dead and waste eaters) we can concentrate on predators and parasites - parasitism being a type of symbiotic relationship.

Predation & Symbiotic Relationships:

A. Some difficulties in distinguishing predators from parasties.

1) General Definitions:

Predator - A large animal which kills and eats smaller ones,
and Prey eg. a lion is a predator of sheep.

Parasite - A small organism that lives off bigger ones,
and Host eg. live flukes & fleas are parasites on sheep.

2) Problems of Distinguishing Predators from Parasites:

Ecological Similarities

Distinguished by Degree of Harm or Mortality

3) Relationships of Modern Man of Predators & Parasites:

INTRODUCTION:

In his cultural evolution man has developed bodies of knowledge concerned with controlling his relationships with other organisms. Two of those disciplines which concern us here are:

a) Agricultural Biology - which is concerned with what man eats. Its aim is to simplify food chains and to eliminate organisms which compete with man for food.

b) Medicine + Public Health - which is concerned with man's being eaten. The goal here is to make man terminal in the food system, that is, to eliminate organisms that eat him.

MAN'S PRESENT RELATIONSHIP TO PREDATORS:

MAN'S PRESENT RELATIONSHIP TO PARASITES:

The material on page 86 may be found

TITLE Biology

AUTHOR Smallwood and Green

PUBLISHER Silver Burdett

PAGE NO. 658-659

Widespread Examples of Predator-Prey Relationships:

Soil Organisms:

Aquatic Organism:

Land Animals:

Reading for Discussion:

AN EXAMPLE OF THE WEB OF COMPLEX DEPENDENCY RELATIONSHIPS.

> "Darwin discovered that bumblebees, because of their long tongues, are the only insects which can effectively pollinate the deep red clover flowers. From this he argued that the success of red clover in England can be attributed to the fact that bumblebees are so prevalent there. He then went on to quote an authority who had found that there were more bumblebee nests in the vicinity of villages and towns than elsewhere because field mice, which eat bumblebee combs and larvae, are scarce around towns. And why are field mice scarce? Because towns usually harbor large numbers of cats which prey upon the field mice and keep their population down. Here a German scientist took up the argument: cats, he said, were thus proved responsible for the prevalence of red clover in England; red clover, a staple food of British cattle, could be ecologically linked to the British navy, whose staple diet was bully beef; hence cats could be given the ultimate credit for Britain's dominance as a world power. Thomas Huxley then went even one step further: he suggested, half-humorously, that since old maids were well known to be the principal protectors of cats throughout all England, the fact that Britannia ruled the waves might logically-and ecologically-be traced right back to the cat-loving tendencies of her many spinsters."
>
> from Ecology, by Peter Farb

Protection from Predators:

1. Concealing, or Protective, Coloration:

2. Mimicry

Predation and the Balance of Nature

Lab Investigation

Name ______________________

Science IIIB Hour ______

Date ______________________

POPULATION CHANGES

Any population of organisms has the ability ro reproduce more of its kind than the environment can support. A single female oyster can produce more than 100 million eggs in one year. If all the eggs produced by existing oysters survived to maturity, and these reproduced in turn, in less than two years the entire world would be covered with a layer of oysters several miles thick. Similar statements could be made about the reproductive potential of almost any population.

Obviously there are many factors that control the growth of populations. These factors include available food supply, predators, the compactness or dispersion of the organisms, and the natural life span of individuals in the population. The interactions of these factors are extremely complex. However, it can be simply stated that if births exceed deaths the population will increase; if deaths exceed births the population will decrease.

In this investigation, you will study the factors of food and temperature in relation to populations of yeasts.

AIM: To investigate factors related to changes in population.

Material:

dry yeast
250-ml beaker
dropping pipettes
stirring rod
microslides
graduated cylinder
gram balance
cane sugar
test tubes
absorbent cotton
compound microscope
hand tally counter
cover glasses

Step A. From a package of dry yeast, select about 15 granules and place them in a 250-ml beaker containing 20 ml of sterile water. Stir until the granules are broken up and the yeast is evenly suspended in the water. Examine a drop of the suspension with the microscope at 100 X.

1. ____

____

Step B. Dilute the yeast suspension by adding 10 ml of water. Stir well, and again examine a drop with the microscope. Continue diluting the suspension, 10 ml at a time, stirring well after each addition of water. Examine with the microscope after each addition until only a few yeast cells (10-15) are visible in the microscope field of view at 100 X.

2. Record the total volume of water you used.

Step C. Divide the diluted yeast suspension into ten equal volumes in test tubes of suitable size. As you pour, keep stirring or agitating the suspension to keep the yeast cells evenly distributed. Cover the test tubes with cotton plugs. Nine tubes will be stored in a refrigerator. One tube will be stored at room temperature for one day. To the tube to be stored at room temperature, add enough sugar to make a 5.0% sugar solution. (A percentage solution is prepared by adding the number of grams equal to the percentage desired to 100 ml of distilled water. For example, to make 100 ml of a 5.0% sugar solution, add 5 grams of sugar to 100 ml of water. To make 50 ml of a 5.0% sugar solution, add 2.5 grams of sugar to 50 ml of water.)

Label the tube to be stored at room temperature with the date and time the sugar was added. Label the tube with the numeral 1.

Step D. On each successive day, remove a test tube from the refrigerator and add sugar to make a 5.0% sugar solution and label with the date and time, as in Step C. Number the tubes consecutively. Store at room temperature.

Step E. At the end of ten days, examine a sample drop from each test tube with the microscope at 100 X. (Stir the suspension in the tube before preparing the slide.) Count the number of cells visible in the field of view from each sample.

3. Record the results.

Tube 1 ________

Tube 2 ________

Tube 3 ________

Tube 4 ________

Tube 5 ________

Tube 6 ________

Tube 7 ________

Tube 8 ________

Tube 9 ________

Tube 10________

4. Plot the results on a graph.

5. Why were nine of the tubes kept covered and refrigerated until the sugar was added?

6. Why was sugar added to each yeast sample?

Lab Investigation

Questions for Review

1. What results would you expect from this investigation? Compare your results with the results you would expect. Does your graph indicate the expected results? Discuss some factors that could affect the final results.

2. What are some factors that control the growth of population of a species in nature?

3. Has the practice of awarding bounties for the killing of such predators as wolves and coyotes adversely affected any species other than wolves and coyotes? Explain your answer.

Further Inquiry:

1. Carry out population studies on organisms such as Drosophila, bacteria, and protozoa.
2. Investigate accounts of the results of introducing organisms into new environments. A well-known example is the introduction of rabbits into Australia.
3. Investigate the patterns of growth of the world's human population.
4. Prepare a hay infusion. Examine it daily over a period of time. Note which organisms gain and lose dominance as the infusion ages.

C. SYMBIOTIC RELATIONSHIPS

Introduction:

Symbiotic relationships within an ecosystem are more intimate than most ecological relationships. In this case individuals from two or more species actually live together and therby establish a more or less permanent physical association with each other. "Symbiosis" literally means "living together". Biologists tend to classify a wide range of symbiotic relationships into three broad patterns. However, this is an arbitrary classification system and is not to be considered rigid and all encompassing.

1) PARASITISM

definitions -

examples -

varities in nature -

extent in nature - According to Karl von Frisch, the well known biologist, it has been calculated that about a quarter of all the animal species known today are either completely parasitic or are parasitic at a particular state of their development. Thus on the average of every fourth animal adopts this mode of life.

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PARASITISM

dependency of parasites

classification of animal parasites

plant parasites

the difference between an "Individual" & a "Single Organism"

The diagram masked out on this page may be found

TITLE Biology

AUTHOR Smallwood & Green

PUBLISHER Silver Burdett

PAGE NO. 660

2) COMMENSALISM:

definition -

examples - plants

animals

3) MUTUALISM:

definition -

examples - plants

animals

The laboratory investigation on pages 96-99 may be found

TITLE Laboratory Investigations in Biology

AUTHOR Smallwood & Green

PUBLISHER Silver Burdett

PAGE NO. 239-245

Additional Questions for Review

1. How can we talk about the balance of nature when our senses tell us that the living world is always changing?

2. How is an organism C̄ protective coloration dependent upon another population C̄ in its ecosystem?

3. How do mutualism and commensalism differ?

4. Why is it difficult to distinguish between some predators and some parasites?

5. How are a prey and a host alike? Different?

6. How has modern man affected his relationships with predators and parasites?

PROBLEMS OF COEXISTENCE WITH THE PHYSICAL ENVIRONMENT

The Development and Distribution of Energy for Power

Utilization of Natural Resources

THE DEVELOPMENT AND DISTRIBUTION OF ENERGY FOR POWER

I. Energy Sources For Producing Power

II. Mechanisms For the Storage of Energy

III. Energy Conversion

IV. Man's Utilization of Energy Resources

V. Other Emerging Power Sources

PROBLEMS ASSOCIATED WITH THE DEVELOPMENT AND DISTRIBUTION OF ENERGY FOR POWER

INTRODUCTION:

ENERGY RESOURCES FOR THE FUTURE*

The history of technology makes it clear that the availability of energy resources upon which to "feed" our present energy-hungry society, and on which to base future technological development, is a matter of serious concern. The seriousness of this question is emphasized by three factors.

First, the world's population is increasing at a tremendous rate as mankind learns to control disease, increases life spans, and generally develops a higher standard of living. This increased population must be fed, clothed, housed and occupied in useful persuits, all of which require the expenditure of energy. The alternatives to meeting the needs of increased population are to be satisfied with a decreasing standard of living for a substantial part of the world's population, or to influence in some way the growth of the population.

Second, even at present population levels, the percapita demand for energy is increasing. Each member of the world's population is increasing his annual use of energy by, on the average, about three percent. This increase is significant, for though it is relatively small in the United States (where energy use per person is about six times that of the world average), it is much larger in areas where consumption is now at a comparatively low level. This increase must be met if mankind is to continue progressing toward what we now view as a better material way of life.

Third, the pattern of energy resource availability is variable with time. Capital resources of energy (coal, oil, natural gas, and so on, the stored energy resources) are discovered, exploited to varying degrees, and eventually depleted to the extent that further extraction is economically impractical. Income resources are developed (the principal example now being hydroelectric resources), and continuing use is made of them for long periods of time. Research and development are also carried on with varying intensity to develop new energy resources. The result is a time-dependent pattern of energy availability for the world.

Any study of energy resources for the future must take into account these and many other aspects of a changing society, both at international and local levels. A consideration of recent history and a study of the many factors that affect energy requirements, however, lead to the inescapable conclusion that somehow mankind must continue to expand its energy resources, and ultimately come to depend heavily on resources which are not now major contributors to the energy economy. Success in these ventures, on the local, national or international level, is necessary if we are to maintain and continually improve the world's standards of living. At the same time, success or failure in these ventures will have far-reaching economic and political implications.

*JOHN A. DUFFIE, Director, UIR Research Program

PROBLEMS ASSOCIATED WITH THE DEVELOPMENT AND DISTRIBUTION OF ENERGY FOR POWER

Resource Material:

Required Reading:

"Emerging Power Sources", Charles J. Lynch, Science and Technology, October, 1967

"The Arrival of Nuclear Power", John F. Hogerton, Scientific American, Feb., 1968

Recommended Reading:

"Longer Range View of Nuclear Energy", Bulletin of Atomic Scientists, Dec., 1960

"A Third Generation of Breeder Reactors", Scientific American, May, 1967

"Report From Rome", Bulletin of Atomic Scientists, Dec., 1961, A Report on the 1961 United Nations Conference Held in Rome - "New Sources of Energy"

"Thermonuclear Power", Science & Technology, Sept., 1965.

For Information About Fusion Reactors:

"Fusion Power", Scientific American Offprint #236, 1957, and the picture a decade later.

"The Leakage Problem", Scientific American, July, 1967

or

"Thermonuclear Power", after 15 years, Science and Technology, Sept. 1965.

QUESTIONS FOR CONSIDERATION:

1. What are the only "natural occuring" energy sources that are available for man to use?

   Discuss the varying degree to which these resources have been exploited.

2. Discuss the difference between "natural occuring energy" and "usable energy".

   Identify the mechanisms and devices which have been developed to convert natural occuring energy to usable energy.

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3. It is said, "In the pure sense all energy available to man is derived from the sun". Assuming this to be true how would you attribute energy derived from gravitational and magnetic forces to the sun? How could one trace the nuclear energy released during the decay of unstable earthbound isotopes to the sun?

4. Discuss the ways in which energy is stored.

   How is the mechanisms of energy storage related to the problem of converting natural energy to usable energy?

5. Why is it, that, in spite of all man's efforts to develop new energy conversion devices over the past 50 years, the mechanical heat engine is still the only practical approach?

   Since the mechanical heat engine serves man's needs for usable energy so well, why is there concern about developing new ways of converting energy?

6. Nuclear reactors are now firmly established as reliable and economically practical suppliers of usuable energy. Can you think of any reasons why man could not develop a technology which would rely exclusively on this method of energy conversion?

7. What broad trends in energy consumption and the development of energy resources are expected during the remainder of this century and during the 21st century?

8. Discuss the difference between "burner" and "converter" types of fission reactors.

9. What is the advantage of the fusion type nuclear reactor over the now existing fission type reactors?

   What is the basic problem now blocking the development of an operable fusion reactor?

   What is the general attitude of the experts in the field of fusion reactor design regarding the possibility of developing a converter of this type?

10. Discuss four different methods by which radiant energy from the sun can be converted into usable energy.

Problems of Coexistence with the Physical Environment

PROBLEMS ASSOCIATED WITH THE DEVELOPMENT AND DISTRIBUTION OF ENERGY FOR POWER

I. Introduction

A. The Unique Energy Requirements of Man

B. Factors Contributing to the Problem of Providing for the Energy Requirements of Man

PROBLEMS ASSOCIATED WITH THE DEVELOPMENT AND DISTRIBUTION OF ENERGY FOR POWER

II. The Energy Sources for Producing Power

  A. Natural Occuring Energy Sources

    1.

    2.

    3.

    4.

III. Energy States: How Energy Exists in Nature

  A. KINETIC ENERGY - energy associated with matter which is in motion

    1. Forms of the Kinetic State

      a) Mechanical

        (1) Macro particle motion

        (2) Sound

        (3) Electrical

      b) Radiant (Electromagnetic Radiation)

        (1) heat

        (2) light

        (3) high energy radiation

B. POTENTIAL ENERGY - "REST" ENERGY or "STORED" ENERGY

Energy associated with Matter by Virtue of Position

1. The Storage of Mechanical Energy
    a) macrobodies at rest
    b) electrical; electrons at rest

2. The Storage of Radiant Energy
    a) chemical bonds, within molecules
    b) nuclear bonds, within atoms

III. Mechanisms for Energy Storage

A. Natural Occuring Storage Mechanisms

B. Man-Made Storage Devices

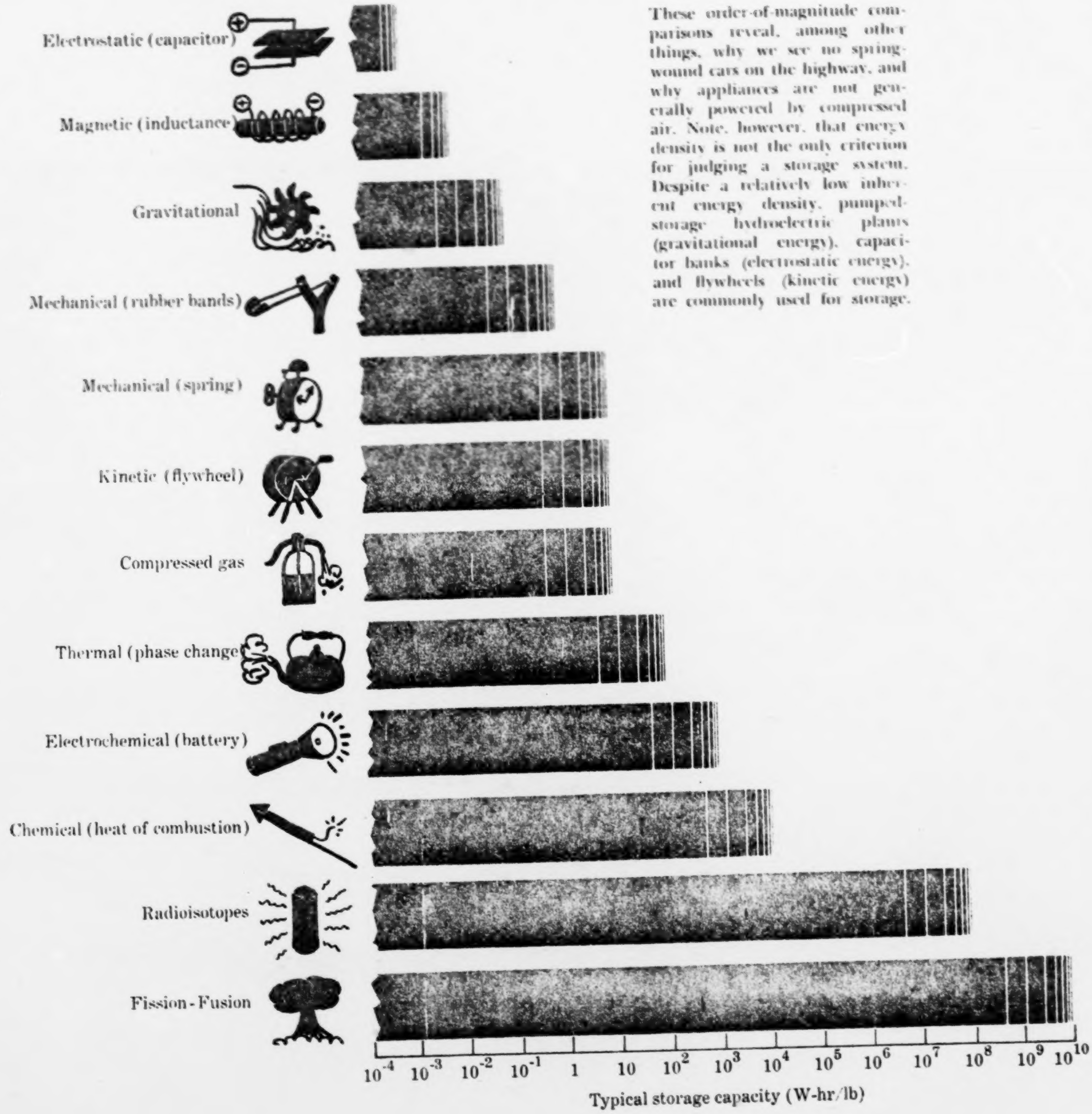
C. Relative Capacity of Storage Mechanisms

1. Unit of Capacity

2. "Energy Capacity" vs "Energy Density"

$w = F \cdot d \ (F//d) \qquad P = \frac{w}{t}$

THE WEIGHT OF A WATT-HR DEPENDS ON HOW IT'S STORED



These order-of-magnitude comparisons reveal, among other things, why we see no spring-wound cars on the highway, and why appliances are not generally powered by compressed air. Note, however, that energy density is not the only criterion for judging a storage system. Despite a relatively low inherent energy density, pumped-storage hydroelectric plants (gravitational energy), capacitor banks (electrostatic energy), and flywheels (kinetic energy) are commonly used for storage.

from: Science and Technology, October 1967, page 38

Laboratory Problem

ENERGY STORAGE BY CHANGING STATE

INTRODUCTION:

One of the techniques that man has learned to use for storing energy is based on the concept of "change of state".

Matter may exist as a solid, liquid, or gas depending on its temperature and the temperature of its surroundings. With very few exceptions, matter can be made to exist in either of these three states. In order to convert solids to liquids, one must put energy into the material.

We know from past experience that it is possible to have ice at a temperature of 0°C and also that water can be a liquid at 0°C. If we were to compare the heat energy possessed by one gram of ice at 0°C to that of one gram of water also at 0°C we would find that the water possesses more energy.

The energy which must be added to one gram of ice at 0°C, to melt it, is retained by the water without causing an increase in the temperature of the water. Apparently this difference in the amount of energy stored by matter in the solid state compared to that which it stores in the liquid state, at the same temperature, is associated with the way in which the molecules are arranged in the two cases. One gram of any material in the liquid state stores more energy than one gram of the same material in the solid state, at the same temperature.

The same situation holds for matter in the liquid and gaseous state. One gram of water as steam at 100°C contains more energy than one gram of water liquid also at 100°C.

Energy stored by matter when it is converted from a solid to a liquid, or, from a liquid to a gas (vapor) is released when the reverse change of state occurs. For example, if 100,000 calories of heat energy was used to convert a certain quantity of liquid water into steam, this "stored" energy could be recovered as heat by simply allowing the steam to condense again into liquid water. Or the energy could be recovered as mechanical energy by allowing the steam to "do work" in some kind of engine.

During the course of the summer months a tremendous amount of energy is stored naturally by the earth. A large percentage of this energy stored is the result of "phase" changes of water, ice to liquid to vapor. During the winter months this energy is released slowly in the reverse phase change. The heat energy associated with these changes of state involving the tremendous quantities of water on the earth helps to keep the temperatures on earth within the tolerable range for life as we know it. Consider the moon for example. It has no water or atmosphere to store and release heat energy. The temperature at the surface of the moon ranges from 212°F during the day to -240°F at night.

Water is not the only substance useful in storing heat energy via change of state. Various other salts and some gases having high heats of fusion and vaporization may also be used as effective heat storage media.

In all thermal energy exchanges the total heat energy gained by one system is equal to the total energy lost by some other system and, of course, no energy exchange is possible unless there is a temperature difference between the two systems.

Laboratory Problem

ENERGY STORAGE BY CHANGING STATE

PROBLEM:

1. How much heat energy is stored (gained) by 1 gram of water when it is converted from ice at 0°C to liquid water at 0°C?
2. How much heat energy is stored (gained) by 1 gram of steam when it is converted from liquid water at 100°C to steam at 100°C?

PROCEDURE:

DATA:

INTERPRETATION OF DATA:

CONCLUSION:

1.

2.

Name ______________________________

Science IIIB Hour _____

Date Due ___________________________

CHANGE OF STATE - ICE TO WATER

Experimental Data:

Weight of calorimeter cup ____________________

Weight of cup plus water ____________________

Weight of stirring rod ____________________

Weight of thermometer ____________________

Weight of cup + water + ice water ____________________

Initial temperature of system ____________________

Final temperature of system ____________________

Interpretation of Data:

Heat Gain	=	Heat Lost
wt · x		wt · Δt · SpHt
(ice in melting) ___ · x		(by water) ___ · ___ · 1.0
wt · Δt · SpHt		(by cup) ___ · ___ · 0.22
(ice water) ___ · ___ · ___		(by rod) ___ · ___ · 0.22
		(by therm) ___ · ___ · 0.18
_____ x	=	____________________

Conclusion:

Heat required to convert one gram of ice at 0°C to water at 0°C is:

____

Laboratory Investigation

CHANGE OF STATE - STEAM TO WATER

Experimental Data:

Weight of calorimeter cup ______

Weight of cup plus water ______

Weight of stirring rod ______

Weight of thermometer ______

Weight of cup + water + condensed steam ______

Initial temperature of system ______

Final temperature of system ______

Interpretation of Data:

Heat Gained = Heat Lost

wt · Δt · SpHt

(by water) ___ · ___ · 1.0

(by cup) ___ · ___ · 0.22

(by rod) ___ · ___ · 0.22

(by therm) ___ · ___ · 0.18

wt · x

(by steam condensing) ___ · x

wt · Δt · SpHt

(by hot water)

___ · ___ · 1.0

___ x = ______

Conclusion:

Heat required to convert one gram of water at 100° C to steam at 100° C is:

______

Name ______________________

Science IIIB Hour ____

Date ______________________

QUESTIONS:

1. What three factors must be taken into account when representing the heat lost or gained by a system?

2. Calculate the amount of heat energy that could be stored by 10,000 grams of water simply by converting it from a liquid at 100°C to vapor at the same temperature.

3. If 1 calorie of heat energy is equivalent to 32 foot pounds of mechanical energy, how much work could be done by a heat engine which reduces 1000 grams of steam at 100°C to water at 100°C each minute? Express your answer in terms of foot pounds per min.

4. Could you store more heat energy in 100 pounds of water at 100°C or at 0°C? Explain.

IV. Energy Conversion

A. The Problem of Energy Conversion

	Natural Forms	Usable Forms
1.		
2.		
3.		
4.		

B. Measurement, Common Units & Equivalents

	CGS	MKS	FPS
mechanical			
heat			
electrical			

C. Power, units describing the rate at which energy is used.

1. FPS
2. CGS
3. MKS

C. Characteristics of a Good Energy Converter

1.

2.

3.

4.

5.

6.

D. Mechanisms for the Practical Conversion of Natural Occuring Energy to Usable Energy

1.

2.

3.

4.

E. Survey of Devices Currently Used For Energy Conversion

Converting Device	Energy Source	Mechanism for Storage of Energy Source	Form of Usable Energy Produced	Efficiency of Conversion
green plant				
animals (muscle power)				
dynamic (reciprocating heat engines)				
turbines				
nuclear reactors				

Exercise

Name ______________________________

Science IIIB Hour _____

Date ______________________________

EQUIVALENCE BETWEEN COMMON ENERGY UNITS

Mechanical	778 ft.lbs.
Heat	1 BTU 252 calories
Electrical	1050 watt sec 3×10^{-4} Kw Hr

454 g = 1 lb

2.54 cm = 1 inch

Heat of Fusion H_2O = 80 cal/g

Heat of Vaporization H_2O = 540 cal/g

1. Assume the chemical bond energy of gasoline is equivalent to 27,000 calories per gram. How many foot pounds of work could be done by the heat energy released when one pound of gasoline is burned?

2. How many Btu's would be required to raise the temperature of 75 gallons of water from 76°F to 160°F? One gallon of water weighs 8.2 lbs.

3. Calculate the amount of electrical energy that would be required to heat the water as described in problem #2.

4. The caloric value of a slice of white bread is reported to be 150 Kilo calories (150C) = 150,000 c. How many foot pounds of energy could be derived from the complete oxidation of this food?

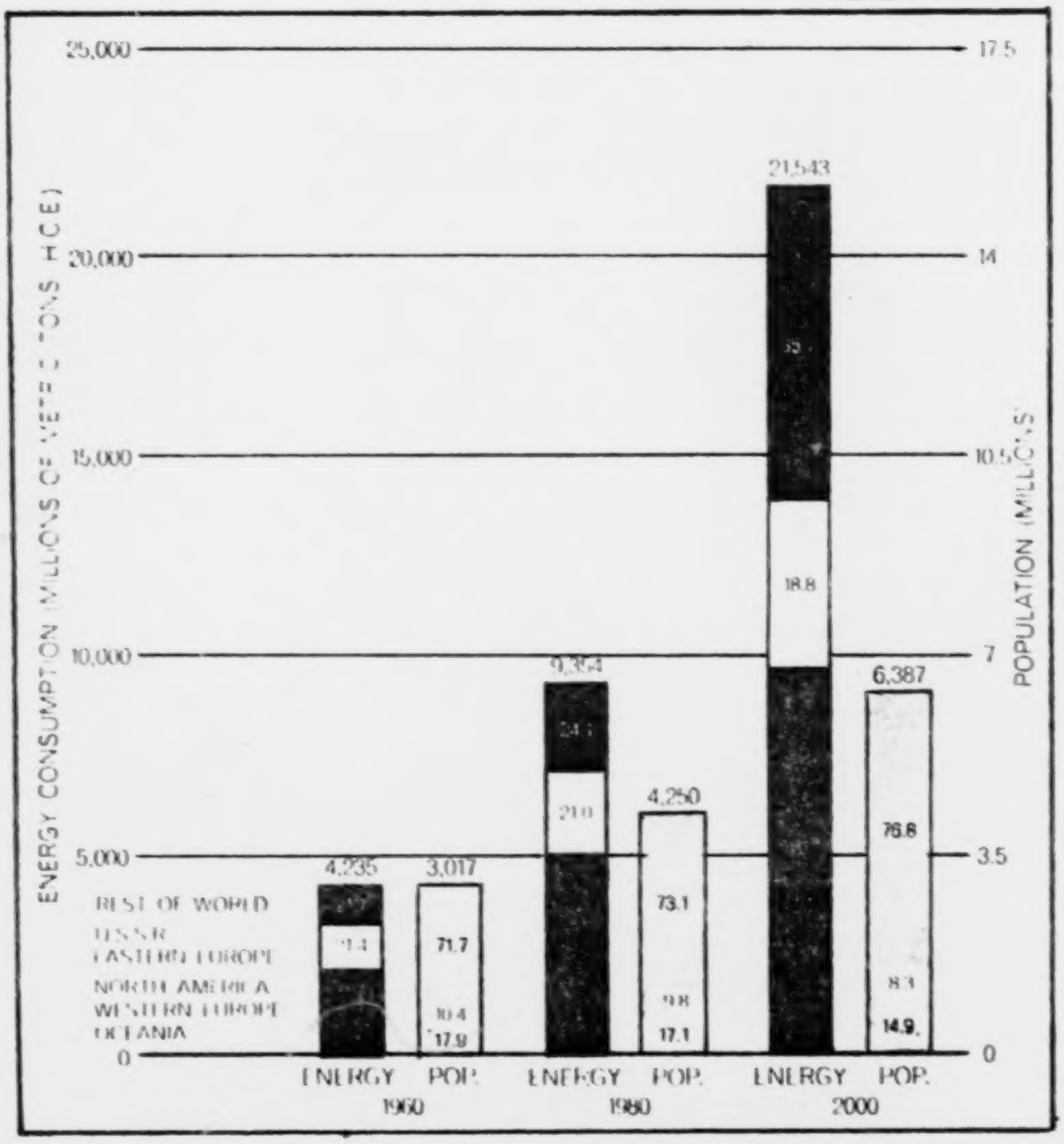
5. The storage capacity of an electrochemical battery is equivalent to 1×10^4 watt hr/lb.

   a. If an auto battery weighs 40 pounds, calculate the electrical energy it could store. Express your answer in Kw Hrs.

   b. Convert this amount of electrical energy to the equivalent amount of mechanical energy.

V. Man's Utilization of Energy Resources

A. Present and Future Energy Requirements



ENERGY CONSUMPTION AND POPULATION projected for 1980 and 2000 are compared with 1960 figures. Over this period energy consumption will rise more than twice as fast as population, with the steepest per capita increase in the non-Western world

1. Projected Statistics on Population and Energy Consumption

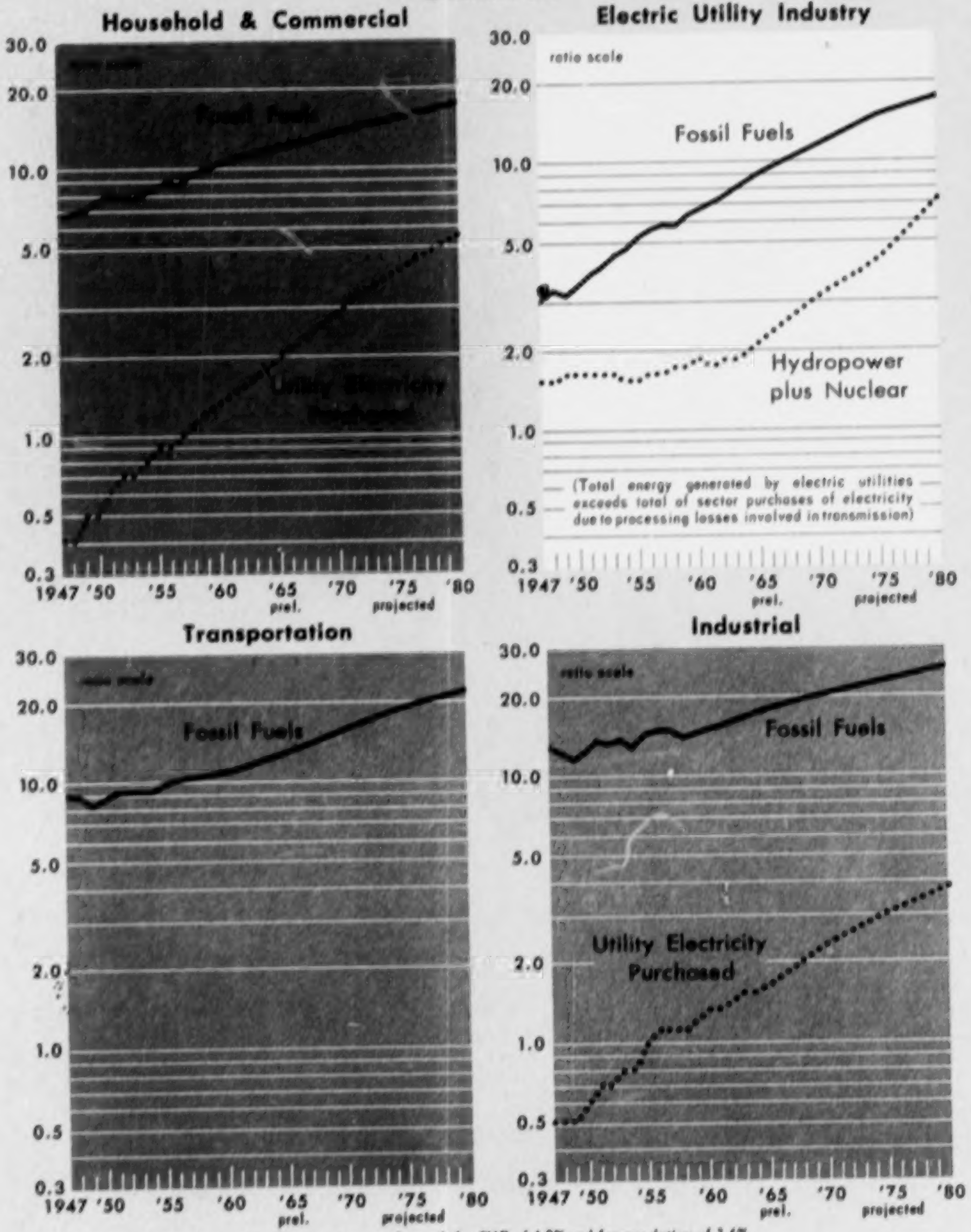
	World Population	Energy Utilization
1960		
1980		
2000		

From: "Energy", Sam Schurr, Scientific American

2. Trends in Utilization of Energy Resources

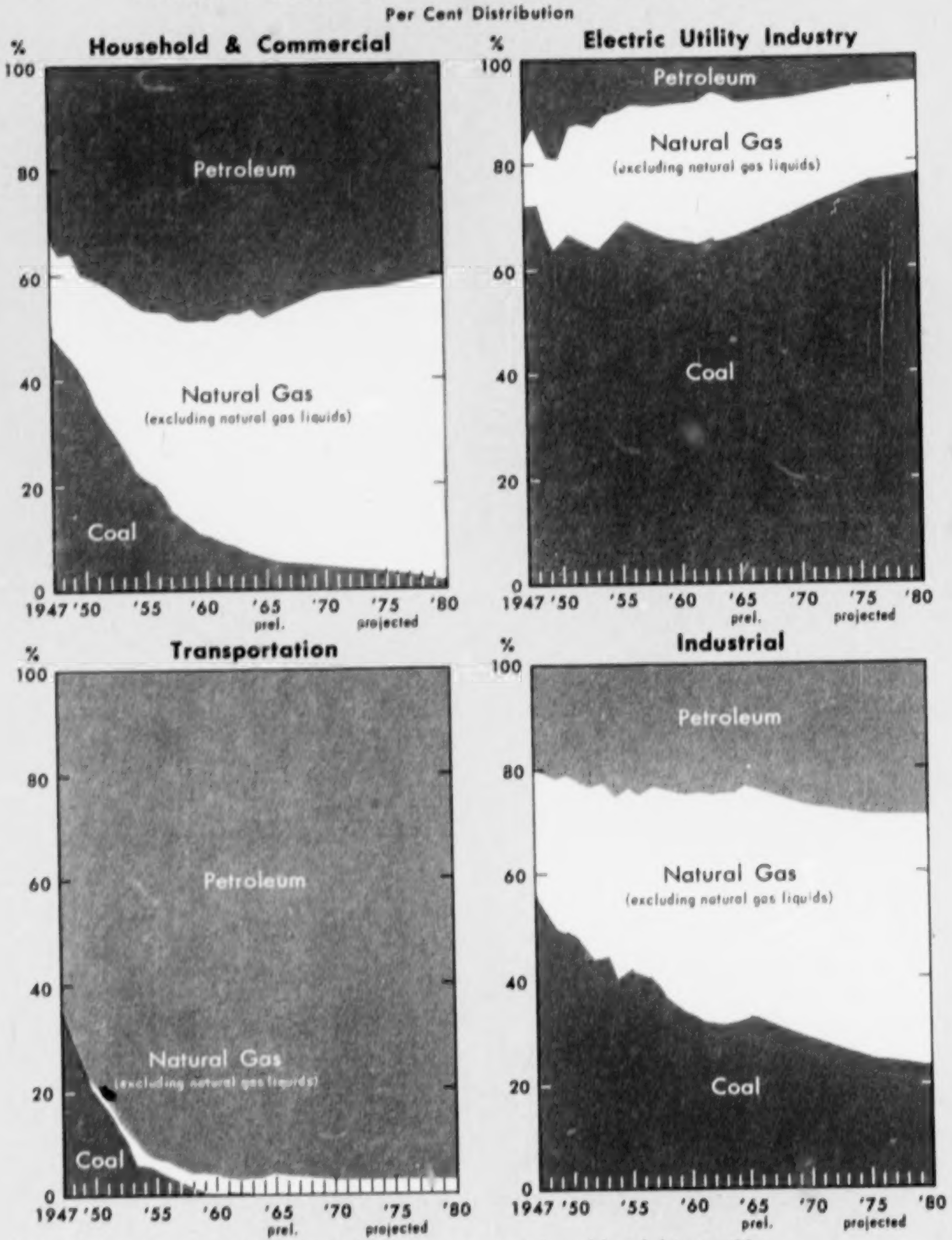
	1930 tons hce	1960 tons hce	2000 tons hce
Solid Fuels (coal)			
Liquid Fuels (petroleum)			
Natural Gas			
Hydroelectric			
Nuclear			

Consumption of Energy Resources By Sector



Note: Projections based on assumed average rates of growth for GNP of 4.0% and for population of 1.6%

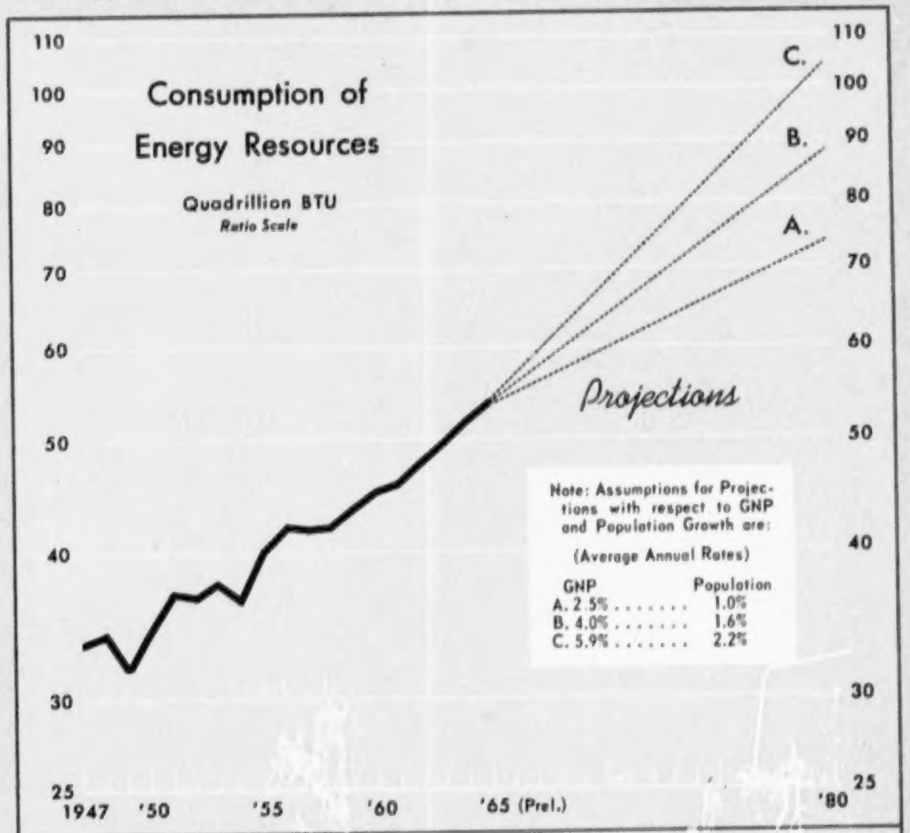
Fossil Fuels Utilized in Each Sector



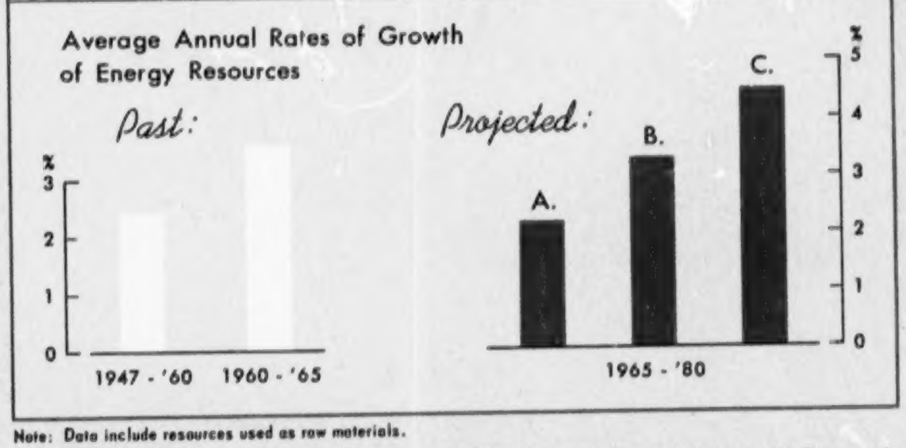
Note: The distribution of fossil fuels utilized is based on the energy equivalents of the underlying quantities

The consumption of energy resources by the transportation sector is projected to increased by 3.7% in the period 1965-80, the fastest rate of the three ultimate consuming sectors shown. The projected rate for the household and commercial sector is 3.5%; for the industrial sector it is 2.7%. These rates of growth reflect energy resources consumed directly as well as those embodied in the electric power purchased. The distribution in 1965 of combined demand by all sectors for fossil fuels was: petroleum, 44% of the total; natural gas (excluding natural gas liquids, which are classed as petroleum), 32%; and coal, the remaining 24%. Little change is projected in this distribution by 1980 despite changes in the demand patterns for each of the sectors.

Energy Resources in the U.S.: Past & Projected


Consumption of Energy Resources

Quadrillion BTU
Ratio Scale


Average Annual Rates of Growth of Energy Resources

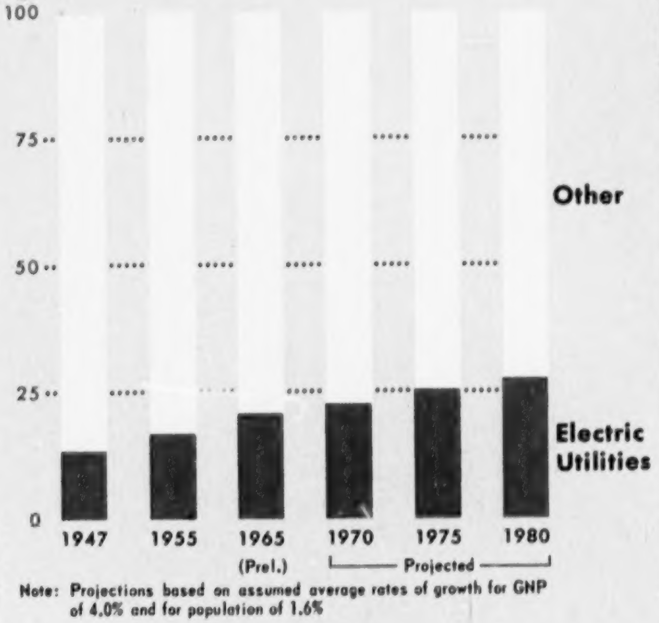
Note: Data include resources used as raw materials.

Demand for energy resources in 1980 may be as high as 105 quadrillion British thermal units (Btu) or as low as 74 quadrillion Btu. This range of projected resource requirements results from the interplay of values of selected variables in a Bureau of the Mines simulation of energy resource requirements in the period 1965-80. Projections A, B, and C, shown above, represent the three cases in which all other variables affecting energy resource demand were held constant, while population and GNP growth rates were varied.

A British thermal unit is the quantity of heat required to raise one pound of water one degree Fahrenheit.

NATIONAL INDUSTRIAL CONFERENCE BOARD, Inc.
No. 1601
September 1, 1968

Energy Supplied by Electric Utilities as Per Cent of Total Energy Resources Consumed

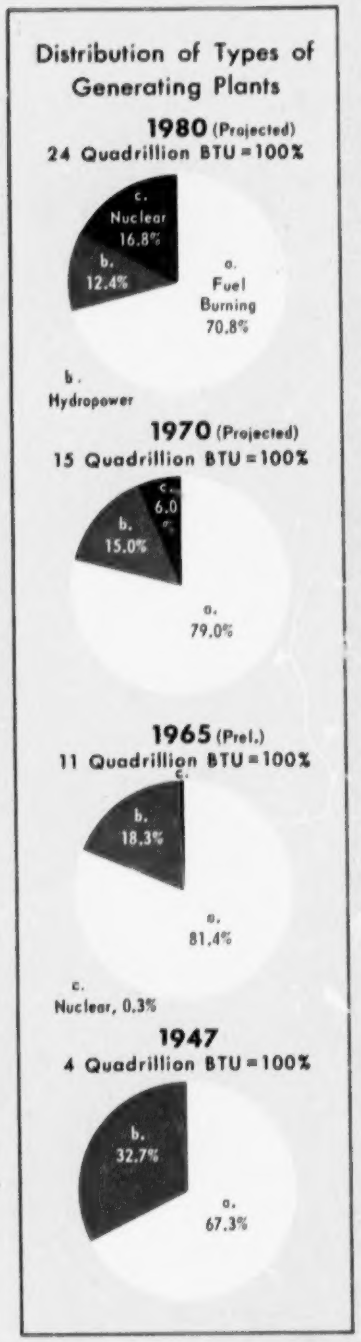


Note: Projections based on assumed average rates of growth for GNP of 4.0% and for population of 1.6%

The demand by electric utilities for energy resources (fossil fuels and hydro and nuclear power) is projected to increase at an average annual rate of 5.4% in the period 1965-80, so that by 1980 they will be consuming 28% of the total; this compares with 21% of the total in 1965.

In 1980, nuclear power will provide over one sixth of the generating capacity of utilities. The breakthrough of nuclear power into commercial utilization was not achieved until the early Sixties; during 1966 and 1967, however, nuclear plants accounted for nearly half of the new power-generating capacity ordered by utilities.

Source: Bureau of the Mines


Distribution of Types of Generating Plants

* * *

Quantities of this chart are available to Associates as follows:
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Prices for larger quantities on request.

ROAD MAPS OF INDUSTRY
J. Frank Gaston, Editor; Allen Frankel; Rosanne Reilly, Chief Chartist
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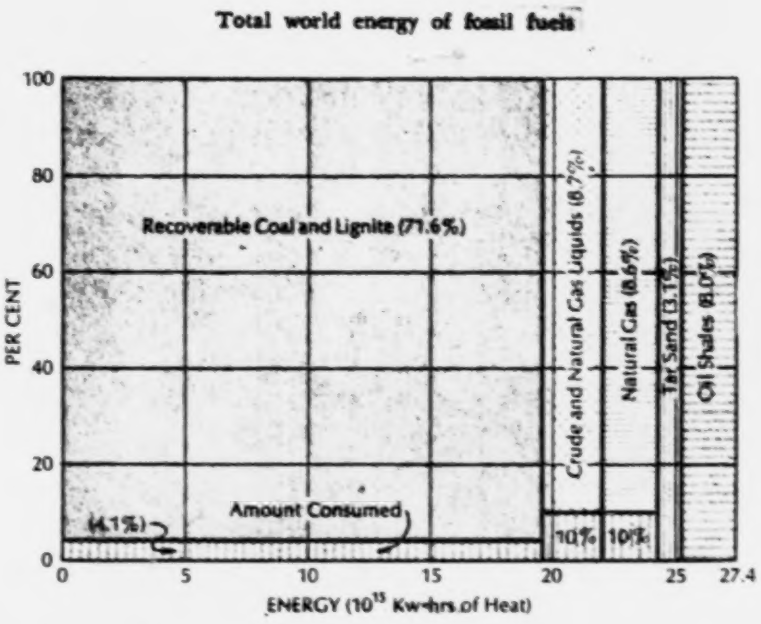
B. The Future of Fossil Fuels

1. Total World Supply of Fossil Fuels

	m tons hce* available	% used
Coal		
Liquid Petro.		
Natural Gas		
Tar Sands		
Oil Shale		

*8.4 x 10^3 Kwhr = 1 m ton hce



(Adapted from *Energy Resources*, National Academy of Sciences).

2. Utilization of Fossil Fuels for Power

	Rate of Utilization	Depletion Date
Coal		
Liquid Petro.		
Natural Gas		
Tar Sands		
Oil Shale		

3. Importance of Fossil Fuels for Non-Power Purposes

a. Organic Syntheis

b. Oxidation - Reduction Reactions

C. The Arrival of Nuclear Power

1. Physical and Chemical Properties of Uranium

a. Occurance
b. Properties of Natural Occuring Isotopes

Isotope	% Occurance in Pure Uranium	Stability
${}^{234}_{92}U$	Traces	NON-Fissionable
${}^{235}_{92}U$	0.3%	Fissionable
${}^{238}_{92}U$	99.7%	NON-Fissionable but "fertile"

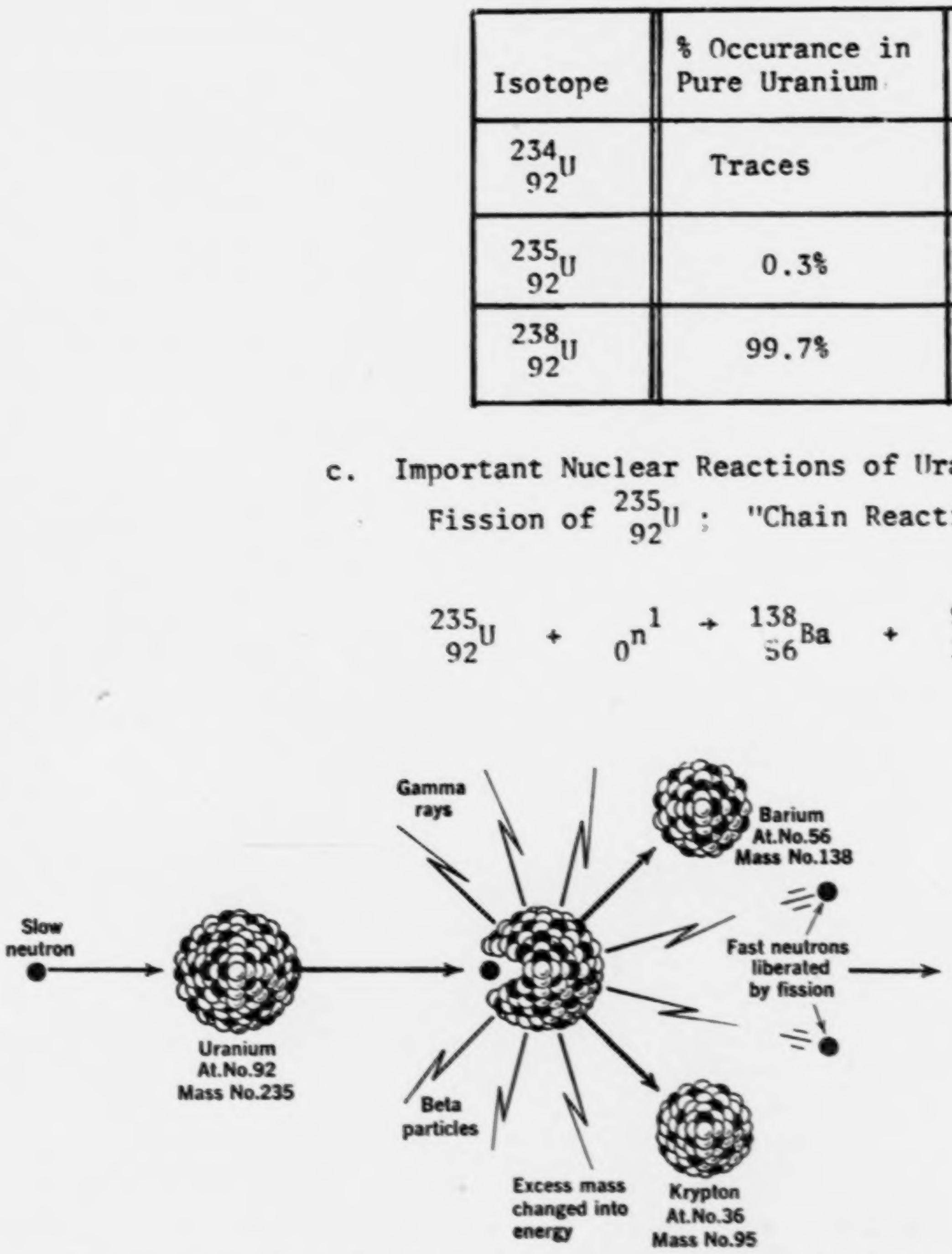
c. Important Nuclear Reactions of Uranium

Fission of ${}^{235}_{92}U$; "Chain Reaction"

$$ {}^{235}_{92}U + {}_{0}n^{1} \rightarrow {}^{138}_{56}Ba + {}^{95}_{36}Kr + 3_{0}n^{1} + \text{energy} $$

*(1.86 x 10^{8} E volts)

*(each amu of matter converted yields 9.31×10^{8} E volts)


Gamma rays
Barium At.No.56 Mass No.138
Slow neutron
Fast neutrons liberated by fission
Uranium At.No.92 Mass No.235
Beta particles
Excess mass changed into energy
Krypton At.No.36 Mass No.95

Neutrons from the fission of one ${}_{92}U^{235}$ nucleus, when slowed down by a moderator, can cause fission in a second ${}_{92}U^{235}$ nucleus. This makes a chain reaction possible.

d. Nuclear Disintegration of ${}^{238}_{92}U$ to Yield "Fissionable" ${}^{239}_{94}Pu$

$$ {}^{238}_{92}U + {}_{0}n^{1} \rightarrow {}^{239}_{92}U \quad \text{(unstable)} $$

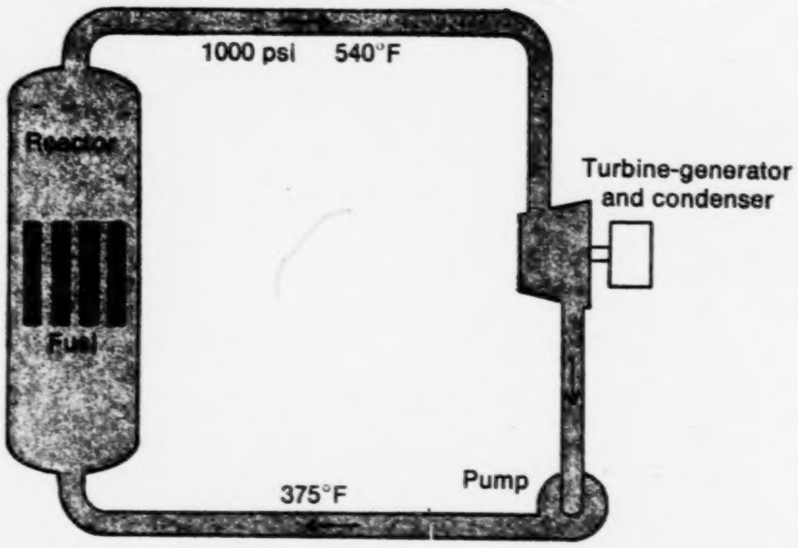
$$ {}^{239}_{92}U \rightarrow {}_{-1}e^{0} + {}^{239}_{93}Np \quad \text{(unstable)} $$

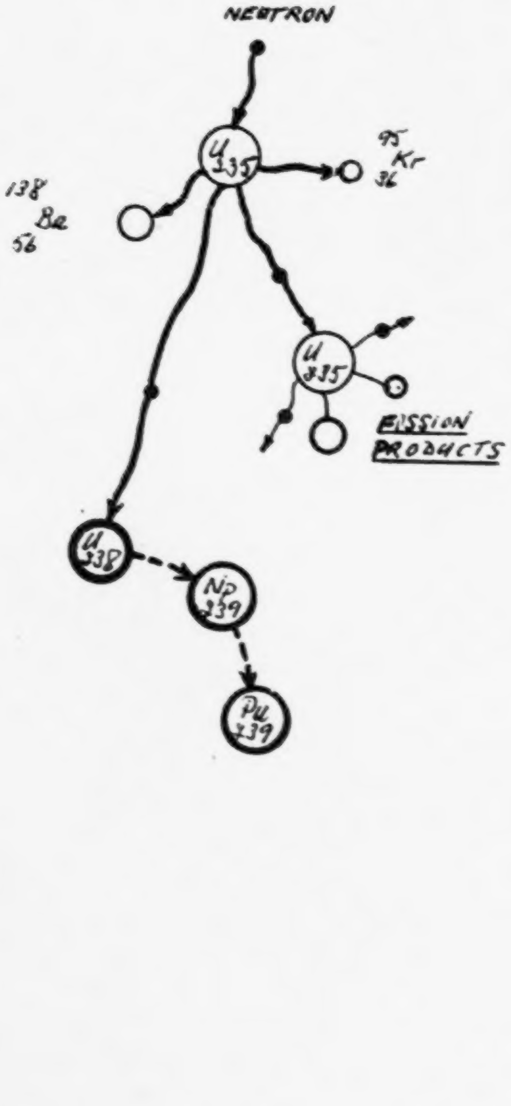
$$ {}^{239}_{93}Np \rightarrow {}_{-1}e^{0} + {}^{239}_{94}Pu \quad \text{(fissionable)} $$

2. Types of Nuclear Reactors

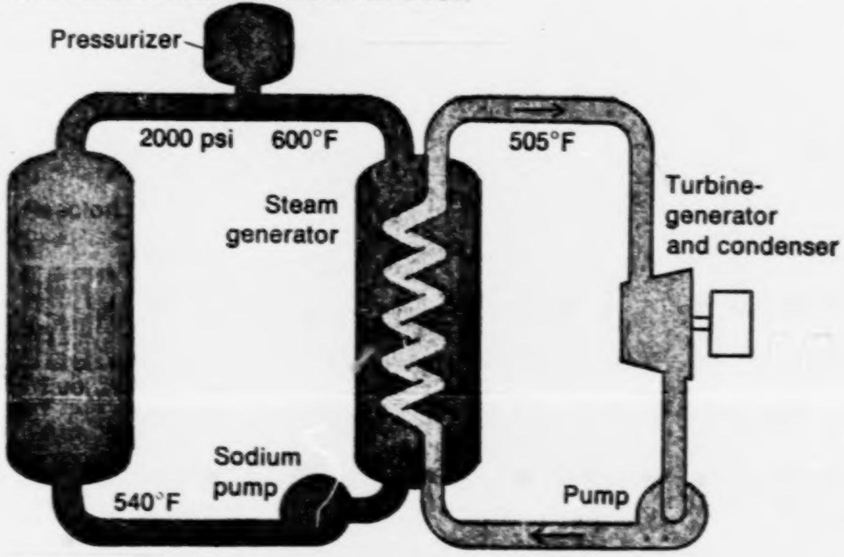
   a. Light Water Reactors
      "Burner Reactors", utilize the energy released in the controlled fusion of ^{235}U in enriched, 2-3%, fuel cells

THE BOILING-WATER REACTOR


1000 psi
540°F
Reactor
Fuel
Turbine-generator and condenser
375°F
Pump


NEUTRON
U 235
95 Kr 36
138 Ba 56
U 235
FISSION PRODUCTS
U 238
Np 239
Pu 239

THE PRESSURIZED-WATER REACTOR


Pressurizer
2000 psi
600°F
505°F
Reactor
Steam generator
Turbine-generator and condenser
Sodium pump
540°F
Pump

Disadvantages of Light Water Reactors

b. Breeder Reactors

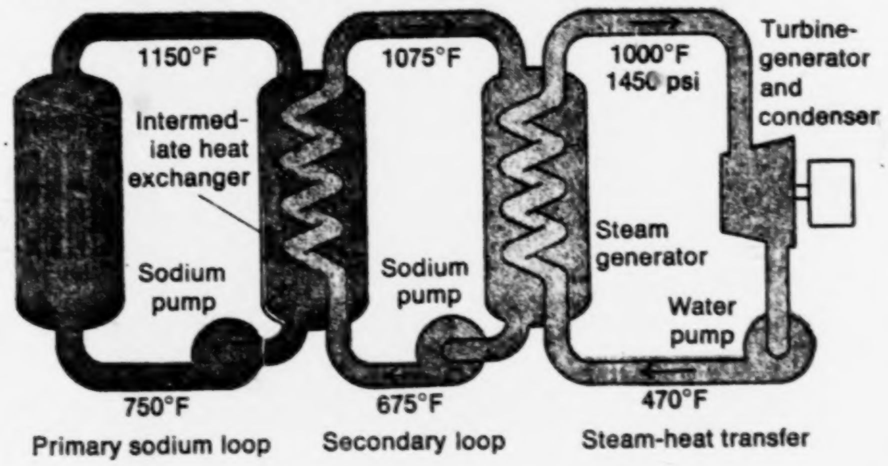
(1) Theory of Breeder Reactors

(2) Conversion Rates

Light Water Reactors (10atoms $^{235}\text{U} \rightarrow 6$ atoms ^{239}Pu)

Theoretical Rates for "Fast Breeder Reactor"

THE LIQUID-METAL-COOLED FAST-BREEDER REACTOR


1150°F
Intermediate heat exchanger
Sodium pump
750°F
Primary sodium loop
1075°F
Sodium pump
675°F
Secondary loop
1000°F
1450 psi
Turbine-generator and condenser
Steam generator
Water pump
470°F
Steam-heat transfer

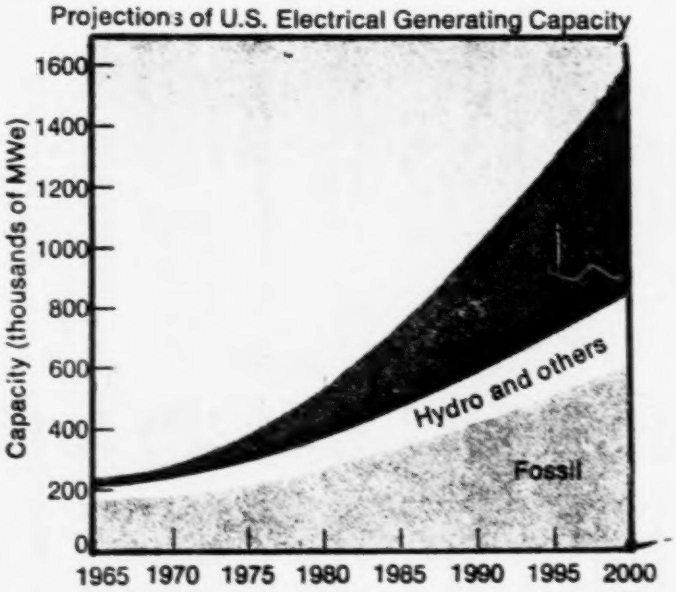
c. Fusion Reactors

(1) Theory of the Reactor

(2) Major Problems

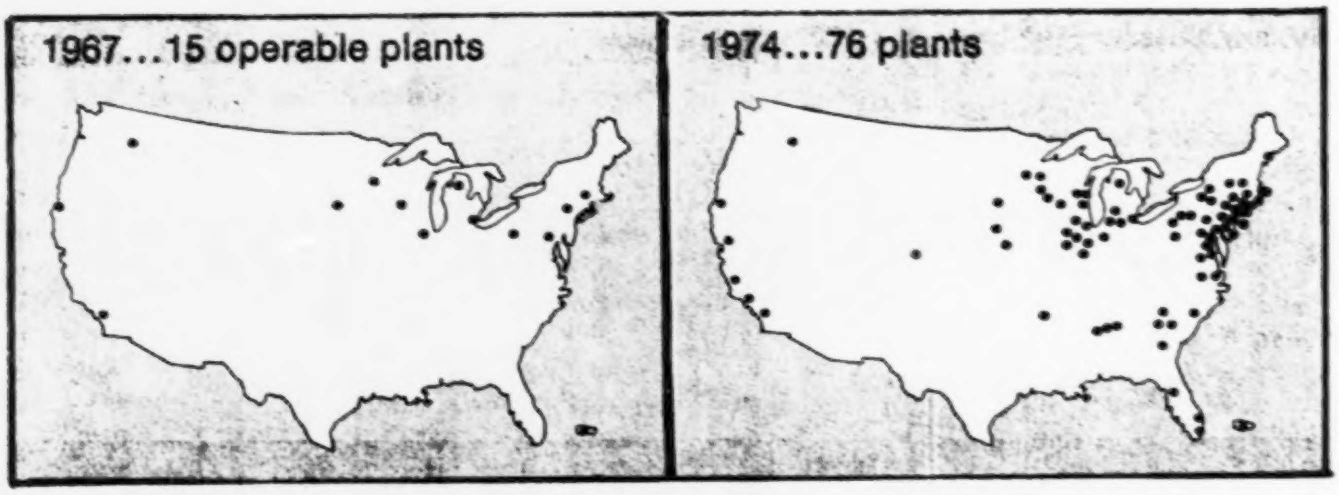
3. Trends in the Conversion of Nuclear Fuels to Usuable Energy

a. Expectations for Electrical Power Production

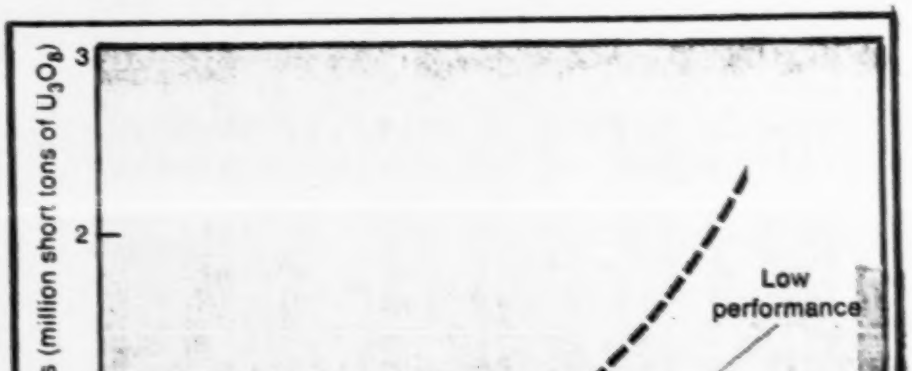


The unexpected surge in orders for nuclear power plants over the past few years has caused continual upward revisions of projections for nuclear power capacity. Right now it looks as if nuclear plants will produce more than half our electric power by the year 2000. This period will also see steady growth in the total U.S. energy consumption and the electrical portion of this total.

b. Growth of Reactor Sites



c. Utilization of Nuclear Fuels Through Year 2000



Present light-water reactor commitments presage a rapidly increasing demand for uranium, as shown by the dotted line. Should fast-breeder reactors come into commercial use during the 1980's, then uranium requirements will be reduced considerably and will level off around the year 2000.

SITE	PLANT NAME	CAPACITY (Kilowatts)	UTILITY	INITIA DESIGN POWER
ALABAMA				
Decatur	Browns Ferry Nuclear Power Plant: Unit 1	1,064,500	Tennessee Valley Authority	1971
Decatur	Browns Ferry Nuclear Power Plant: Unit 2	1,064,500	Tennessee Valley Authority	1972
Decatur	Browns Ferry Nuclear Power Plant: Unit 3	1,064,500	Tennessee Valley Authority	1972
Houston County	Joseph M. Farley Nuclear Plant	829,000	Alabama Power Co.	1975
ARKANSAS				
London	Arkansas Nuclear One	850,000	Arkansas Power & Light Co.	1972
CALIFORNIA				
Humboldt Bay	Humbolt Bay Power Plant: Unit 3	68,500	Pacific Gas & Electric Co.	1963
San Clemente	San Onofre Nuclear Generating Station	430,000	Southern Calif. Edison and San Diego Gas & Electric Co.	1967
Corral Canyon	Malibu Nuclear Plant: Unit1	462,000	L.A. Dept of Water & Power	1975
Diablo Canyon	Diablo Canyon Nuclear Power Plant: Unit 1	1,060,000	Pacific Gas & Electric Co.	1973
Diablo Canyon	Diablo Canyon Nuclear Power Plant: Unit 2	1,060,000	Pacific Gas & Electric Co.	1974
Clay Station	Rancho Seco Nuclear Generating Station	800,000	Sacramento Municipal District	1972
COLORADO				
Platteville	Ft. St. Vrain Nuclear Generating Station	330,000	Public Service Co. of Colorado	1972
CONNECTICUT				
Haddam Neck	Conn. Yankee Atomic Power Plant	575,000	Conn. Yankee Atomic Power Co.	1967
Waterford	Millstone Nuclear Power Station: Unit 1	652,100	Northeast Utilities	1970
Waterford	Millstone Nuclear Power Station: Unit 2	828,000	Northeast Utilities	1974
FLORIDA				
Turkey Point	Turkey Point Station: Unit 3	651,500	Florida Power & Light Co.	1971
Turkey Point	Turkey Point Station: Unit 4	651,500	Florida Power & Light Co.	1972
Red Level	Crystal River Plant: Unit 3	858,000	Florida Power Corp.	1972
Ft. Pierce	Hutchinson Island	800,000	Florida Power and Light Co.	1973
GEORGIA				
Baxley	Edwin I. Hatch Nuclear Plant	786,000	Georgia Power Co.	1973
ILLINOIS				
Morris	Dresden Nuclear Power Station: Unit 1	200,000	Commonwealth Edison Co.	1960
Morris	Dresden Nuclear Power Station: Unit 2	809,000	Commonwealth Edison Co.	1970
Morris	Dresden Nuclear Power Station: Unit 3	809,000	Commonwealth Edison Co.	1970
Zion	Zion Nuclear Plant: Unit 1	1,050,000	Commonwealth Edison Co.	1971
Zion	Zion Nuclear Plant: Unit 2	1,050,000	Commonwealth Edison Co.	1973
Cordova	Quad-Cities Station: Unit 1	809,000	Comm. Ed. Co.–Ia.–Ill. Gas & Elec. Co.	1970
Cordova	Quad-Cities Station: Unit 2	809,000	Comm. Ed. Co.–Ia.–Ill. Gas & Elec. Co.	1971
INDIANA				
Dunes Acres	Bailly Generating Station	515,000	Northern Indiana Public Service Co.	1976
IOWA				
Cedar Rapids	Duane Arnold Energy Center: Unit 1	545,000	Iowa Electric Light and Power Co.	1973
MAINE				
Wiscasset	Maine Yankee Atomic Power Plant	790,000	Maine Yankee Atomic Power Co.	1972
MARYLAND				
Lusby	Calvert Cliffs Nuclear Power Plant: Unit 1	800,000	Baltimore Gas and Electric Co.	1973
Lusby	Calvert Cliffs Nuclear Power Plant: Unit 2	800,000	Baltimore Gas and Electric Co.	1974
MASSACHUSETTS				
Rowe	Yankee Nuclear Power Station	175,000	Yankee Atomic Electric Co.	1961
Plymouth	Pilgrim Station	625,000	Boston Edison Co.	1971
MICHIGAN				
Big Rock Point	Big Rock Point Nuclear Plant	70,300	Consumers Power Co.	1963
South Haven	Palisades Nuclear Power Station	700,000	Consumers Power Co.	1970
Lagoona Beach	Enrico Fermi Atomic Power Plant: Unit 1	60,900	Detroit Edison Co.	1963
Lagoona Beach	Enrico Fermi Atomic Power Plant: Unit 2	1,126,000	Detroit Edison Co.	1974
Bridgman	Donald C. Cook Plant: Unit 1	1,054,000	Indiana & Michigan Electric Co.	1972
Bridgman	Donald C. Cook Plant: Unit 2	1,060,000	Indiana & Michigan Electric Co.	1973
Midland	Midland Nuclear Power Plant: Unit 1	492,000	Consumers Power Co.	1973
Midland	Midland Nuclear Power Plant: Unit 2	818,000	Consumers Power Co.	1974
MINNESOTA				
Elk River	Elk River Nuclear Plant	22,000	Rural Cooperative Power Assoc.	1964
Monticello	Monticello Nuclear Generating Plant	545,000	Northern States Power Co.	1970
Red Wing	Prairie Island Nuclear Generating Plant: Unit 1	530,000	Northern States Power Co.	1972
Red Wing	Prairie Island Nuclear Generating Plant: Unit 2	530,000	Northern States Power Co.	1974
NEBRASKA				
Fort Calhoun	Ft. Calhoun Station: Unit 1	457,400	Omaha Public Power District	1971
Brownville	Cooper Nuclear Station	778,000	Consumers Public Power District and Iowa Power and Light Co.	1972

SITE	PLANT NAME	CAPACITY (Kilowatts)	UTILITY	INITIAL DESIGN POWER
NEW HAMPSHIRE				
Seabrook	Seabrook Nuclear Station	860,000	Public Service Co. of N.H.	—
NEW JERSEY				
Toms River	Oyster Creek Nuclear Power Plant: Unit 1	515,000	Jersey Central Power & Light Co.	1969
Toms River	Oyster Creek Nuclear Power Plant: Unit 2	1,100,000	Jersey Central Power & Light Co.	1978
Salem	Salem Nuclear Generating Station: Unit 1	1,050,000	Public Service Gas and Electric Co. of New Jersey	1972
Salem	Salem Nuclear Generating Station: Unit 2	1,050,000	Public Service Gas and Electric Co. of New Jersey	1973
Newbold Island		1,100,000	Public Service Gas and Electric, NJ	1975
Newbold Island		1,100,000	Public Service Gas and Electric, NJ	1977
NEW YORK				
Indian Point	Indian Point Station: Unit 1	265,000	Consolidated Edison Co.	1963
Indian Point	Indian Point Station: Unit 2	873,000	Consolidated Edison Co.	1971
Indian Point	Indian Point Station: Unit 3	965,300	Consolidated Edison Co.	1973
Scriba	Nine Mile Point Nuclear Station	500,000	Niagara Mohawk Power Co.	1969
Rochester	R.E. Ginna Nuclear Power Plant: Unit 1	420,000	Rochester Gas & Electric Co.	1969
Shoreham	Shoreham Nuclear Power Station	819,000	Long Island Lighting Co.	1975
Lansing	Bell Station	838,000	New York State Electric & Gas Co.	1978
Verplanck	Verplanck: Unit 1	1,115,000	Consolidated Edison Co.	1975
Scriba	James A. Fitzpatrick Nuclear Power Plant	821,000	Power Authority of State of N.Y.	1973
NORTH CAROLINA				
Southport	Brunswick Steam Electric Plant: Unit 1	821,000	Carolina Power and Light Co.	1975
Southport	Brunswick Steam Electric Plant: Unit 2	821,000	Carolina Power and Light Co.	1976
•		821,000	Carolina Power and Light Co.	—
•		1,100,000	Duke Power Co.	1977
•		1,100,000	Duke Power Co.	1979
OHIO				
Oak Harbor	Davis-Besse Nuclear Power Station	872,000	Toledo Edison-Cleveland Electric Illuminating Co.	1974
Moscow	William H. Zimmer Nuclear Power Station	840,000	Cincinnati Gas & Electric Co	1975
OREGON				
Rainier	Trojan Station	1,106,000	Portland General Electric Co.	1974
PENNSYLVANIA				
Peach Bottom	Peach Bottom Atomic Power Station: Unit 1	40,000	Philadelphia Electric Co.	1967
Peach Bottom	Peach Bottom Atomic Power Station: Unit 2	1,065,000	Philadelphia Electric Co.	1971
Peach Bottom	Peach Bottom Atomic Power Station: Unit 3	1,065,000	Philadelphia Electric Co.	1973
Limerick Township		1,065,000	Philadelphia Electric Co.	1975
Limerick Township		1,065,000	Philadelphia Electric Co.	1977
Shippingport	Shippingport Atomic Power Station: Unit 1	90,000	Duquesne Light Co.	1957
Shippingport	Beaver Valley Power Station: Unit 1	847,000	Duquesne Light Co.–Ohio Edison Co.	1973
Goldsborough	Three Mile Island Nuclear Station: Unit 1	831,000	Metropolitan Edison Co.	1971
Goldsborough	Three Mile Island Nuclear Station: Unit 2	810,000	Metropolitan Edison Co.	1973
•	—	1,052,000	Pennsylvania Power and Light	1976
•	—	1,052,000	Pennsylvania Power and Light	1977
SOUTH CAROLINA				
Hartsville	H.B. Robinson S.E. Plant: Unit 2	700,000	Carolina Power & Light Co.	1970
Seneca	Oconee Nuclear Station: Unit 1	841,100	Duke Power Co.	1971
Seneca	Oconee Nuclear Station: Unit 2	886,000	Duke Power Co.	1972
Seneca	Oconee Nuclear Station: Unit 3	886,000	Duke Power Co.	1973
TENNESSEE				
Daisy	Sequoyah Nuclear Power Plant: Unit 1	1,124,000	Tennessee Valley Authority	1973
Daisy	Sequoyah Nuclear Power Plant: Unit 2	1,124,000	Tennessee Valley Authority	1974
VERMONT				
Vernon	Vermont Yankee Generating Station	513,900	Vermont Yankee Nuclear Power Corp.-Green Mt. Power Corp.	1971
VIRGINIA				
Gravel Neck	Surry Power Station: Unit 1	780,000	Virginia Electric & Power Co.	1971
Gravel Neck	Surry Power Station: Unit 2	780,000	Virginia Electric & Power Co.	1971
Mineral	North Anna Power Station: Unit 1	845,000	Virginia Electric & Power Co.	1974
WASHINGTON				
Richland	N-Reactor/WPPSS Steam	790,000	Washington Public Power Supply System	1966
WISCONSIN				
Genoa	LaCrosse Boiling Water Reactor	50,000	Dairyland Power Cooperative	1969
Two Creeks	Point Beach Nuclear Plant: Unit 1	497,000	Wisconsin Michigan Power Co.	1970
Two Creeks	Point Beach Nuclear Plant: Unit 2	497,000	Wisconsin Michigan Power Co.	1972
Carlton	Kewaunee Nuclear Power Plant: Unit 1	527,000	Wisconsin Public Service Co.	1972

* Site not selected

d. Consumption of Electrical Energy

(1) In the United States

YEAR	TOTAL	ELECTRICAL	% ELECTRICAL
1960			
2000			

(2) World Consumption

YEAR	TOTAL	ELECTRICAL	% ELECTRICAL
1960			
2000			

Supply of Nuclear Fuel in Tons of U_3O_8 Ore	Cost of Recovery $/Pound	Energy Equivalent and Years to Depletion (based on year 2000 World Energy Requirement)								
		U^{235} Only (Burner Reactor)			Converter Reactor			Breeder Reactor		
		3.57x10'' HCE	YEARS 18.2% Electrical	YEARS 60% Elec.	3.57x10'' HCE	YEARS 18.2% Elec.	YEARS 60% Elec.	3.57x10'' HCE	YEARS 18.2% Elec.	YEARS 60% Elec.
9×10^5	10	0.39			0.78			56		
3.5×10^6	20	1.35			2.7			190		
8×10^6	30	3.5			7			500		
30×10^6	50	13			26			1850		
80×10^6	100	35			70			5000		

Name ______________________________

Laboratory Investigation

Science IIIB Hour ___

Date ______________________________

Solar Radiation

INTRODUCTION:

The radiant energy emitted by our sun is the result of a continuous fusion reaction near the sun's surface. In this reaction atoms of hydrogen are being fused into helium. The sun is in fact a "fusion reactor". Scientists believe that the nuclear reaction on the sun is the same as that proposed for man-made fusion reactors on earth.

$$^{2}_{1}D + ^{3}_{1}T \longrightarrow ^{4}_{2}He + ^{1}_{0}n + \text{ENERGY}$$

It has been calculated that in this reaction on the sun 4.7 million tons of hydrogen isotopes are being converted to helium each second. Considering this rate of "burn" one would suspect that the sun would soon burn itself out. However, calculations which take into account the size of the sun and this rate of "burn" indicate that over a period of 400,000 years the sun would convert only 3% of its mass into energy.

Only a tiny fraction of the energy radiated outward from the sun as a result of this fusion reaction ever reaches the earth's surface. The energy is radiated outward from the sun in all directions, like spokes on a wheel. The energy travels as a wave, in straight lines, and thus spreads out as distance from the sun is increased. Since the earth is relatively small and very far away it intercepts only a small percentage of the radiant energy travelling away from the sun. Some of the energy radiated toward the earth's surface is absorbed by our atmosphere but approximately half of it gets through and is incident upon the earths surface.

PURPOSE OF THE INVESTIGATION

In this investigation we will attempt to measure the intensity of the solar radiation which reaches the earth's surface and determine how the intensity of this radiation is affected by the angle at which the waves strike the surface. We shall also measure the difference between "beam radiation" and total radiation and from this data calculate the percentage of "diffuse radiation" at the earth's surface.

PROCEDURE

I. Measurement by Insulation Meter

Place the columnating tube over the insulation meter and measure the level of beam radiation perpendicular to the surface of the instrument. Remove the columnating tube and measure the total radiation. The difference between these two is the scattered "diffuse" radiation.

DATA:

Beam Radiation ⊥ to surface = ______________ Ly/min

Total Incident radiation = ______________ Ly/min

diffuse radiation = ______________ Ly/min

II. Direct Measurement of Radiation Intensity

Wrap blanket insulation around the calorimeter cup, making sure that the entire area below the ring support is covered. Hold this insulation in place with a string tied loosely. Cut circular patches of insulation to cover the bottom and top of the calorimeter. The top piece must have an opening cut out of the center to permit the radiation to pass through and be absorbed by the water in the calorimeter cup.

Add about 100 ml of water to the calorimeter cup. The temperature of the water must be the same as the outdoor temperature!

Close the calorimeter and tilt it so that the cover of the instrument is perpendicular to the rays of the sun. Measure the starting temperature. Allow solar radiation to enter the instrument for at least 30 min. Measure the final temperature of the water at the conclusion of the experiment.

CUP EMPTY	CUP + H_2O	STIRR. ROD	TEMP START	TEMP END

Name ______________________________

DATA:

Date ________________ TIME (START) ________________

Sky conditions ________________ TIME (END) ________________

F_w cal cup empty ________________

F_w cal cup + water ________________

F_w stirring rod ________________

F_w thermometer ________________

Outdoor temperature at start of exp. ________________

Outdoor temperature at end of exp. ________________

Water temperature at start ______________

Water temperature at end ______________

Diameter of opening in cover of calorimeter

Interpretation of Data:

Heat Energy Gained

by calorimeter cup $F_w \cdot \Delta t \cdot$ SpHt

by stirring rod $F_w \cdot \Delta t \cdot$ SpHt

by thermometer $F_w \cdot \Delta t \cdot$ SpHt

by water $F_w \cdot \Delta t \cdot$ SpHt ________________

TOTAL calories

AREA OF OPENING IN CALORIMETER COVER

$A = \pi r^2 =$ ______ cm^2

Average Solar Radiation = ________________ Ly/min (cal/min/cm^2)

III. Effect of angle of incidence on the intensity of radiation received.

Mount the insulation meter in a position so that its surface is perpendicular to the incoming radiation. This is most easily done by adjusting the position of the instrument to give a maximum reading.

Record the total radiation being received. Swing the instrument from the perpendicular position through 90°. Take intensity readings each 10 degrees.

Angle of Incidence (degrees)	Total Radiation (Ly/min)
90°	____________
70°	____________
50°	____________
40°	____________
30°	____________
20°	____________
10°	____________
0°	____________

Prepare a graph to show the relationship of intensity of radiation received as a function of the angle of incidence.

QUESTIONS:

1. What is the average intensity of "total" solar radiation incident upon a surface perpendicular to the rays of the sun?__________________

2. What % of the total solar radiation perpendicular to a surface is

   a) beam radiation ____________

   b) scattered radiation ______________

Name ______________________________

3. Use your data to calculate the quantity of radiation that would fall upon a surface area 1 meter square in one hour.
Assume an average angle of incidence of 70 degrees.

4. Assume that 60% of the energy incident upon the surface described above was absorbed by water.

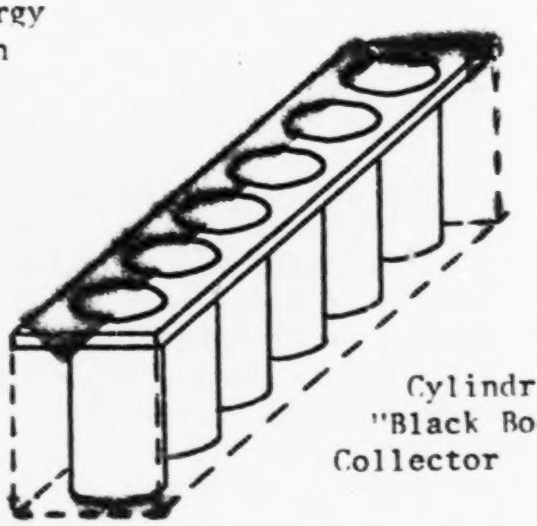
   a) In one hour this would equal ____________ calories.

   b) Considering that 252 cal = 1 Btu = 778 ft.lbs. and that $\frac{550 \text{ ft lbs}}{\text{sec}}$ = 1 horsepower; Calculate the power equivalent of the radiation in Hp.

THEORY:

The efficiency of conversion is based on the energy balance between the solar radiation incident upon the surface of the converter and the thermal energy transferred to the water.

(Radiant Energy In = Thermal Energy Collected + Energy Lost)



Cylindrical "Black Body" Collector

Solar radiation is measured with an instrument called an "insolation meter". The standard unit for solar radiation is the Langley per minute (Ly/min). Radiant energy equivalent to 1 Ly/min is sufficient energy to raise the temperature of 1 g. of water 1 degree Centigrade in one minute when the area of exposure is one centimeter squared. In other words,

$$\text{One Langley per Minute} = \text{One gram calorie per minute centimeter}^2$$

Thermal energy transmitted by the device can be measured in terms of the temperature rise in the water.

$$\text{Thermal Energy Gained} = F_{wH_2O} \cdot \Delta t \cdot \text{SpHt}$$

The collector device in our design is based on the principle of the "black body" absorber. A perfect black body would be a device capable of absorbing 100% of the energy incident upon its aperture. A perfect black body does not actually exist and the blackened cylinders used in this device are far from being "perfect" absorbers. One question of interest is how the efficiency of a collector of this design compares to that of "flat plate" collectors now in use.

PROBLEM:

a. To compare the efficiency of a "black body" type thermal collector to the 60% efficiency acheived by flat plate type collectors.

b. To determine what percent of radiant energy incident upon the "black body" is lost by the reradiation of energy through the aperture of the device.

PROCEDURE:

Orient the collector surface and the sensing cell of the insolation meter in a horizontal plane. The experimental study is to be made in response to total radiation received on a horizontal surface. Radiation measurements should be made every minute. The total radiation input during the course of the experiment will be based on the average of the radiation levels measured each minute during the course of the experiment. The initial and final temperatures of the water are the most critical measurements to be made in the course of the experiment. Great care should be taken in order to assure that these values are determined with an accuracy of ± 0.1°C.

In the investigation half of the cylindrical "black body" collector units will be covered with clear plastic to prevent reradiation of energy through the top. The remaining units will not be covered.

Name ______________________________

Science IIIB Hour ______

Date ______________________________

THE DIRECT CONVERSION OF SOLAR RADIATION TO USABLE THERMAL ENERGY

EXPERIMENTAL DATA:

Time (min)	Incident Radiation	Time (min)	Incident Radiation
1		16	
2		17	
3		18	
4		19	
5		20	
6		21	
7		22	
8		23	
9		24	
10		25	
11		26	
12		27	
13		28	
14		29	
15		30	

Date: ______________________________

Time of Day: ____________________

Outdoor Temperature: ______________

Collector Covered _____ Not Covered _____

Surface Area of Collector __________

Grams of Water Used ______________

Percent of Transmittance for the Plastic Cover: ϕ = ____________________

(for covered units, energy input equals $\phi \cdot$ Ly/min.)

Initial Water Temperature __________

Final Water Temperature ___________ (± 0.1°C)

INTERPRETATION OF DATA:

Energy Input (calories)

(avg. Ly.min · Area · time)

$$\frac{\text{cal}}{\cancel{\text{m}}\text{in}\ \text{c}\cancel{\text{m}}^2} \cdot \text{c}\cancel{\text{m}}^2 \cdot \cancel{\text{m}}\text{in}$$

Energy Input = __________

Energy Absorbed (calories)

$F_w \cdot \Delta t \cdot$ SpHt

____

Energy Absorbed = __________

Energy Lost = __________

CONCLUSION:

Efficiency of Collector with Cover ______________________

Efficiency of Collector without Cover ______________________

Apparent percent of energy lost by the cylindrical collector as a result of reradiation through the aperture ______________________

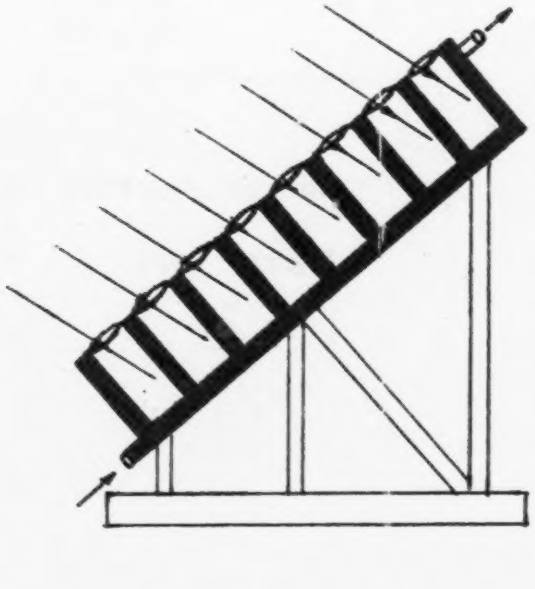
QUESTIONS:

1. Assume a thermal collector, 1 by 2 meters, with an overall collection and storage efficiency of 60%. If the average radiation over an 8 hour period is 0.84 Ly.min, how many calories of usable heat would this unit provide?

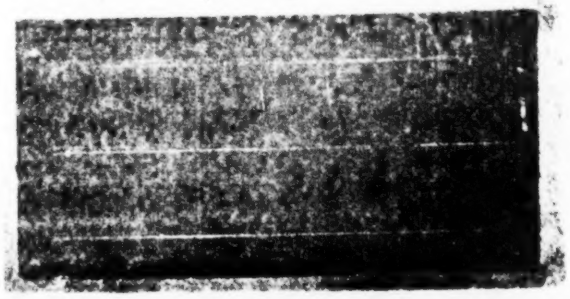
   ____

2. Assume that the unit described above was used in conjunction with a system designed to circualte water through the collector unit at just the right rate to produce a temperature rise of 40°C. How many liters of water could be heated in an 8 hour period? (Assume no heat losses in water movement.)

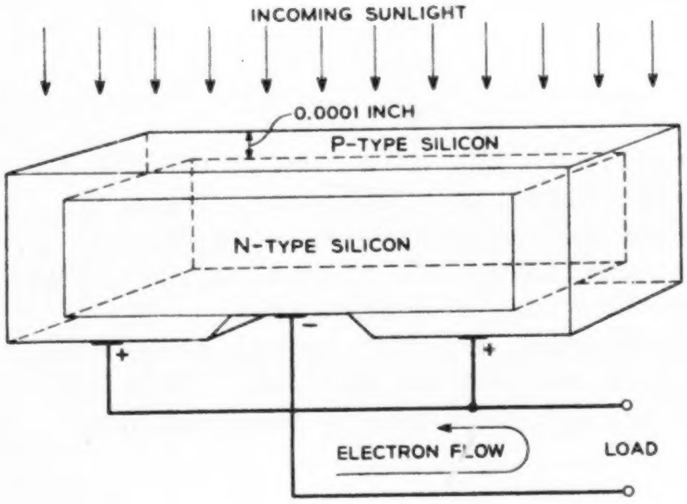
   ____



3. Photoelectric Converters

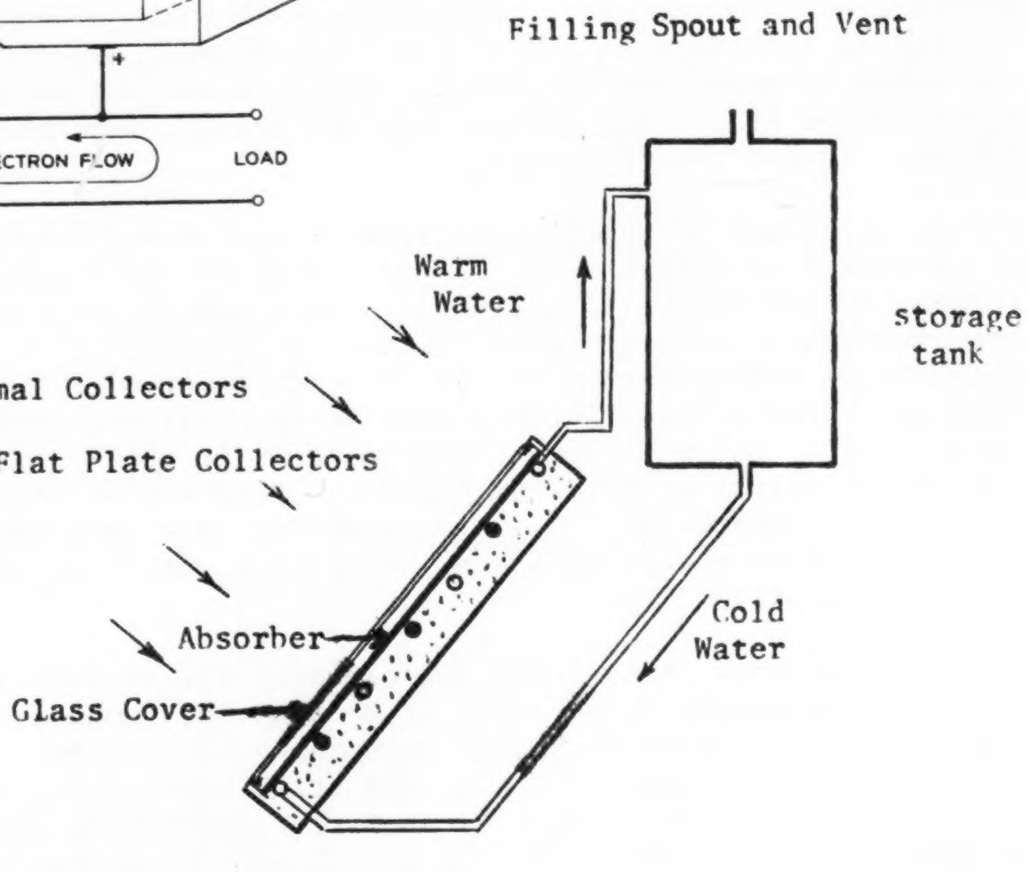


A gridded p-n cell


INCOMING SUNLIGHT
0.0001 INCH
P-TYPE SILICON
N-TYPE SILICON
+
−
+
ELECTRON FLOW
LOAD

4. Thermal Collectors

a. Flat Plate Collectors


Filling Spout and Vent
Warm Water
storage tank
Absorber
Glass Cover
Cold Water

b. "black body" collectors

Laboratory Investigation

THE DIRECT CONVERSION OF SOLAR RADIATION TO USABLE THERMAL ENERGY

INTRODUCTION:

The total amount of natural energy available to man as a result of solar radiation incident upon the surface of the earth is tremendous. Most of the world receives on the average of about 500 kilocalories of solar energy per square foot per day. This is equivalent to approximately 20 million calories per acre per day. Considering that in the United States, the per capita land area is about 13.5 acres/person, the per capita solar energy available is about 280 million kilocalories per person per day. This is nearly 2,000 times more energy than the present per capita requirements for fuel in the United States.

The total amount of energy available at the earth's surface, though great, is presently of little significance for direct utilization by man because it reaches the earth in so diffuse a form and at such low temperatures. The development of techniques for the utilization of solar radiation involve problems of concentration as well as conversion of the natural energy source. Although these problems have proved to be difficult ones to solve, the direct conversion of solar energy to usable forms is not impossible. In addition to the technological problems of building systems that work, there is also the problem of competition. A system must not only work, but, to be successful, it must produce energy at a cost which is competitive with other methods of energy production.

Presently we know of four mechanisms which may be used to convert solar radiation to usable forms. One of these, photosynthesis, is a natural photochemical process which has been going on for some time. The products of photosynthesis have provided, and still constitute, man's major usable energy resource. Other methods of direct conversion involve thermal absorption, the thermal electric effect and the photoelectric effect. Devices employing the three latter mechanisms have been built, but so far their power per cost ratios **far exceed** those achieved by devices which produce power by burning fossil fuels.

One of the areas of solar energy utilization which shows promise for practical domestic application in the near future is solar heating (energy capture and transfer by thermal absorption). Certain materials which have high coefficients of thermal absorption and conductance can be used to collect solar energy over fairly large areas and time periods. The energy thus collected can be transferred to and stored in water or other materials with high specific heats. The extraction of the energy is then simply a matter of providing for temperature differences. Devices successfully implementing these processes could be used for domestic water heating and for space heating.

In this experiment we will design a "thermal collector" and measure the efficiency with which it is able to collect and transfer solar radiation to water.

V. Geophysical Power Sources

A. Hydroelectric - Tidal

B. Wind

C. Terrestrial Heat

Current Utilization	Estimated Maximum

D. Atmospheric Electricity

VI. Other Emerging Power Sources

A. Devices for the Conversion of Solar Energy

1. Thermoelectric Devices

2. Thermionic Generators

B. Fuel Cells

  1. Theory of Operation

    a. Historical Development

      (1) 1839 - Sir William Grove

      (2) 1885 - Ludwig Mond and Carl Langer

      (3) 1957 - Union Carbide - First Practical Application

    b. Mechanism of the Chemical Reaction

    c. Efficiency of Operation

      (1) Theoretical

      (2) Actual

  2. Future of Fuel Cells

    a. remote Power Sources

    b. Portable Power Units

VII. A Hypothetical Energy System for 2000 A.D.

Source of Energy	Percentage of Total Energy Input to the System
Income Energy	
fuel wood	2.7
farm wastes	1.8
water power	0.9
solar heat collectors for space	9.1
heating in middle latitudes	0.1
solar cookers and solar power collectors in arid zones	0.2
tidal power	nominal
terrestrial heat (heat pumps)	nominal
Total Income Energy	15 Percent
Capital Energy	
residual fossil fuels	25
nuclear fuels	60
Total Capital Energy	85 Percent

TOTAL SYSTEM 100 Percent
(2.1×10^{10} tons hce per year)

Exercise

Name ______________________

Science IIIB Date ____________

Energy Conversion

1. The following data was obtained in an experiment conducted to determine the heat of vaporization of water.

Initial wt of calorimeter cup + water = 204g
wt of calorimeter cup = 46g (SpHt = 0.2)
wt of thermometer = 20g (SpHt = 0.18)
wt of stirring rod = 10g (SpHt = 0.2)
Final wt of calorimeter cup + water = 215g

The temperature of the calorimeter at the start of the experiment was 20°C. The final temperature was 50°C. Calculate the heat of vaporization of the water.

2. In an experiment to determine the heat of fusion for water the following data was obtained.

Initial wt of calorimeter cup + water = 180g
wt of calorimeter cup = 54g (SpHt = 0.2)
wt of thermometer = 20g (SpHt = 0.18)
wt of stirring rod = 10g (SpHt = 0.2)
Final wt of calorimeter cup + water = 208g

The temperature of the calorimeter at the start of the experiment was 18°C. The final temperature was 6°C. Calculate the heat of vaporization of water.

3. a) 252 calories = 1 Btu and 1 Btu = 778 ft lbs of mechanical energy

Calculate the amount of work done by a heat engine which reduces 1000g of steam at 100°C to water at 100°C each minute. (Heat of vaporization for water = 540 cal/g.)

b) $\frac{550 \text{ ft lbs}}{\text{min}}$ = 1 horse power. Calculate the power output of the machine.

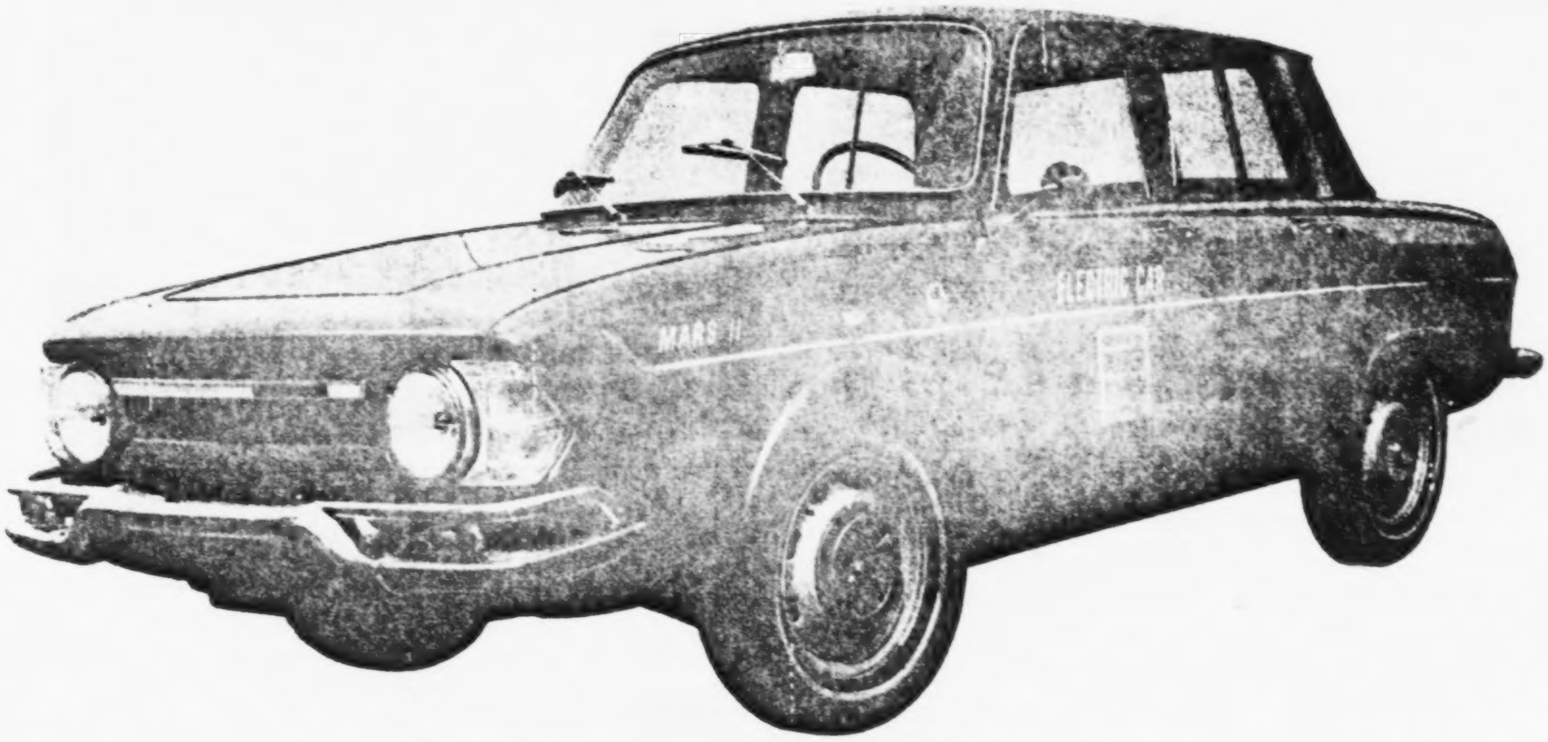
4. Assume that the average radiation received at the surface of the earth during a 12 hour period equals 0.8 Ly/min. Calculate the amount of heat energy, in calories, that would be received upon an area of 1 meter^2 during this time period.

5. 252 calories = 1050 watt sec = $3X10^{-4}$ KwHr

   Assume that the area described in problem #4 was covered with solar cells which were able to convert 14% of the energy incident upon their surface into electrical energy. Calculate the electrical energy, in KwHr, that could be derived from the system during the 12 hour period.

6. Assume that a flat plate collector having an efficiency of 60% and an area equal to 1 meter^2 received an average of 0.8 Ly/min during a 10 hour period. If the collector takes in water at 20°C and heats it to 60°C how many pounds of water could be heated during the 12 hour period?

Wisconsin Power and Light Company's



MARS II Electric Car

SPECIFICATIONS

Size:	4-door, 5-passenger sedan (Uses Renault R-10 body).
Dimensions:	Length: 167½" Width: 60" Height: 55½" Wheelbase: 89" Ground Clearance: 5"
Weight:	4000 pounds.
Motor:	15 Horsepower, Direct Current, Variable speed to 4000 RPM.
Batteries:	30 kilowatt lead-cobalt type for motor. 12 volt lead-cobalt type for lights and accessories.
Charger:	Built-in, overnight recharging, 230-volt circuit.
Transmission:	4 speeds forward, 1 reverse.
Brakes:	Hydraulic disc brakes on all four wheels. Mechanical parking brake.
Range:	70 to 120 miles in normal city driving.
Speed:	60 miles per hour maximum.
Acceleration:	0 to 40 MPH in 10 seconds.
Tires:	5.5 x 15 radial ply.
Suspension:	4-wheel independent suspension.
Other Features:	Heater and defroster, Padded dash, Fully reclining seats, Seat belts, Windshield washer, Four-way flasher, Child-guard locks on rear doors, Undercoated and rustproofed body.
Price:	$4,800.

WISCONSIN POWER AND LIGHT
An Investor Owned COMPANY

PIONEERING WITH ELECTRIC PROPULSION

This MARS II electric automobile was the first unit off the production line at Electric Fuel Propulsion, Inc. in Ferndale, Michigan. Wisconsin Power and Light Company was the first utility in the world to purchase this advanced design electric car. The car has a maximum range of 120 miles on a full charge and a top speed of 60 miles per hour. It is equipped with a built-in charging unit, which permits a complete recharge overnight.

IMPROVED BATTERIES MAKE IT POSSIBLE

The heart of the MARS II is a unique 120 volt, 30 kilowatt power system designed by Electric Fuel Propulsion. It consists of 20 six-volt, high capacity, lead-cobalt batteries. This system provides about double the energy available in ordinary lead-acid batteries of the same weight. The batteries can be completely recharged 800 times (equivalent to a driving range of 56,000 to 96,000 miles).

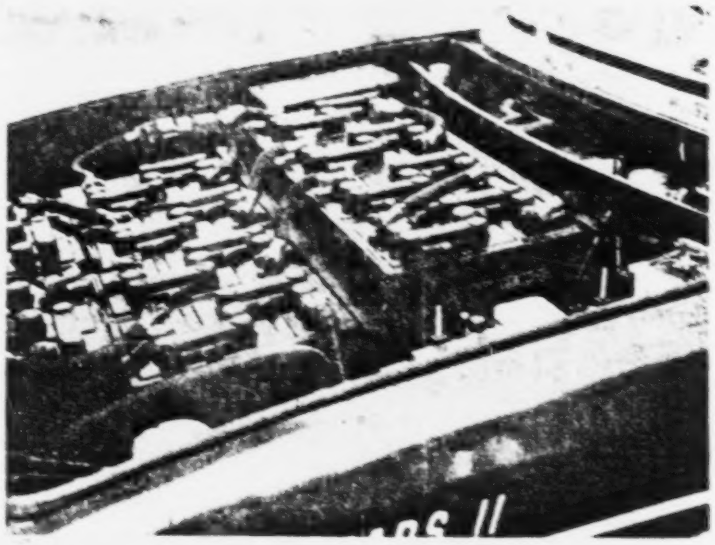
IS THE ELECTRIC CAR PRACTICAL?

A recent Gallup Poll revealed that 36 million adults in this country would be interested in buying an electric car. Over 45,000 electric trucks are in daily use in England. In Germany, 100-passenger, battery-powered electric trains are in operation. Electric golf carts and electric forklift trucks are commonplace all over the world today.

Even with new Federal requirements for exhaust emission controls on internal combustion engines, today's gas automobiles are still the major contributor to our nation's air pollution problems. Electric cars eliminate this source of air contamination.

Electric cars are extremely quiet. They are also economical. They use no fuel while standing at a stoplight. They are durable. The electric car's simplicity eliminates a number of complicated parts required for more conventional vehicles. Greater durability and simplicity mean less maintenance and repair.

Since an electric motor delivers full power at all speeds, the car does not require the shifting of gears while in motion. Although the MARS II has a four-speed transmission, it has all the advantages of an automatic transmission. There is no clutch and the gears are not shifted while the car is in motion. Third gear is used for normal city driving. First and second gears provide greater power and economy while the car is climbing steep hills. Fourth gear offers the speed necessary for expressway driving.



WISCONSIN POWER & LIGHT
An Investor Owned COMPANY

A BRIGHT FUTURE

The MARS II represents a major step toward the practical electric car. Continued research and development to improve batteries, electric motors, battery chargers, control systems and electric braking systems undoubtedly will lead to even greater electric automobile performance.

For example, MARS III, the successor to MARS II, is already on the drawing board. This model will be of completely original design with a streamlined body and many other improvements and refinements. The range for this vehicle is projected at 350 miles and plans call for a top speed of 100 miles per hour.

Several other companies are engaged in research on electric cars and power systems. Our Company is contributing to research on a new zinc-air battery system in association with the Edison Electric Institute. This new type of power source is under development in the laboratories at the General Atomics Division of General Dynamics, Inc. In addition, experimental models are now being tested by some companies and a variety of electric power systems are under laboratory investigation throughout the country.

The electric cars built today are rather costly since they are either one-of-a-kind models or custom modifications of gasoline engine vehicles. Increased electric car sales will eventually lead to mass production and more competitive prices. Even today, the future of electric cars appears bright and this means a brighter future for the electric power utilities that will keep them running.

PERIODIC CHART

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TRANSITION

LIGHT METALS

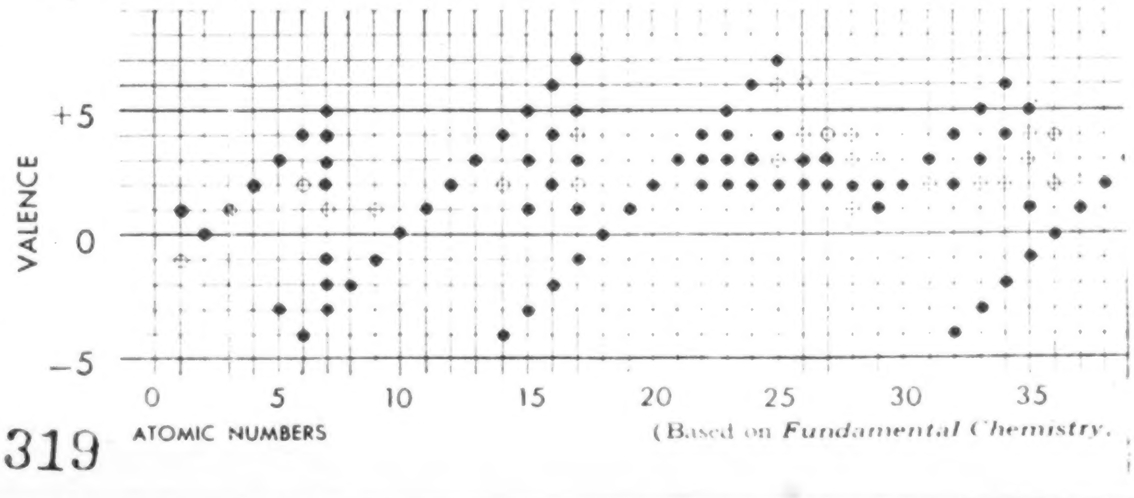
SHELLS PRINCIPAL QUANTUM No. *n*	SHELLS X-RAY NOTATION	I A	II A	III B	IV B	V B	VI B	VII B
1	K	1 1 H 1.00797						
2	L	2 1 3 Li 6.939	2 2 4 Be 9.0122					
3	M	2 8 1 11 Na 22.9898	2 8 2 12 Mg 24.312					
4	N	2 8 8 1 19 K 39.102	2 8 8 2 20 Ca 40.08	2 8 9 2 21 Sc 44.956	2 8 10 2 22 Ti 47.90	2 8 11 2 23 V 50.942	2 8 13 1 24 Cr 51.996	2 8 13 2 25 Mn 54.9380
5	O	2 8 18 8 1 37 Rb 85.47	2 8 18 8 2 38 Sr 87.62	2 8 18 9 2 39 Y 88.905	2 8 18 10 2 40 Zr 91.22	2 8 18 12 1 41 Nb 92.906	2 8 18 13 1 42 Mo 95.94	2 8 18 13 2 43 Tc (99)
6	P	2 8 18 18 8 1 55 Cs 132.905	2 8 18 18 8 2 56 Ba 137.34	57-71 See Lanthanide Series	2 8 18 32 10 2 72 Hf 178.49	2 8 18 32 11 2 73 Ta 180.948	2 8 18 32 12 2 74 W 183.85	2 8 18 32 13 2 75 Re 186.2
7	Q	2 8 18 32 18 8 1 87 Fr (223)	2 8 18 32 18 8 2 88 Ra 226	89-100 See Actinide Series				

6 P	LANTHANIDE SERIES (Rare Earth Elements)
7 Q	ACTINIDE SERIES

NOTE: A value given in parentheses denotes the mass number of the isotope of the longest known half-life, or of the best known one.

*The brackets are meant to indicate only the general order of subshell filling. The filling of subshells is not completely regular, as is emphasized by the use of red ink to denote shells which have electron populations different from the preceding element. In the case of He, subshell population is not by itself indicative of chemical behavior, and that element is therefore included in the *inert gas* group, even though helium possesses no p-electrons.

Open circles represent valence states of minor importance, or those



(Based on *Fundamental Chemistry*,

OF THE ELEMENTS

REVISED, 1964

p

INERT GASES

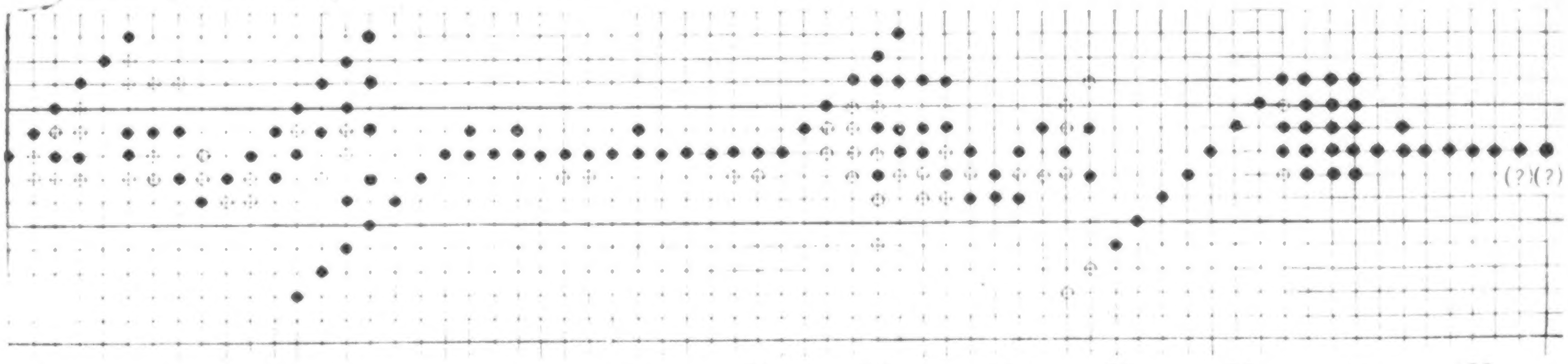
HEAVY METALS

NON METALS

VIII			I B	II B	III A	IV A	V A	VI A	VII A	INERT GASES
										2 2 He 4.0026
					2 3 5 B 10.811	2 4 6 C 12.01115	2 5 7 N 14.0067	2 6 8 O 15.9994	2 7 9 F 18.9984	2 8 10 Ne 20.183
					2 8 3 13 Al 26.9815	2 8 4 14 Si 28.086	2 8 5 15 P 30.9738	2 8 6 16 S 32.064	2 8 7 17 Cl 35.453	2 8 8 18 Ar 39.948
2 8 14 2 26 Fe 55.847	2 8 15 2 27 Co 58.9332	2 8 16 2 28 Ni 58.71	2 8 18 1 29 Cu 63.54	2 8 18 2 30 Zn 65.37	2 8 18 3 31 Ga 69.72	2 8 18 4 32 Ge 72.59	2 8 18 5 33 As 74.9216	2 8 18 6 34 Se 78.96	2 8 18 7 35 Br 79.909	2 8 18 8 36 Kr 83.80
2 8 18 15 1 44 Ru 101.07	2 8 18 16 1 45 Rh 102.905	2 8 18 18 46 Pd 106.4	2 8 18 18 1 47 Ag 107.870	2 8 18 18 2 48 Cd 112.40	2 8 18 18 3 49 In 114.82	2 8 18 18 4 50 Sn 118.69	2 8 18 18 5 51 Sb 121.75	2 8 18 18 6 52 Te 127.60	2 8 18 18 7 53 I 126.9044	2 8 18 18 8 54 Xe 131.30
2 8 18 32 14 2 76 Os 190.2	2 8 18 32 15 2 77 Ir 192.2	2 8 18 32 17 1 78 Pt 195.09	2 8 18 32 18 1 79 Au 196.967	2 8 18 32 18 2 80 Hg 200.59	2 8 18 32 18 3 81 Tl 204.37	2 8 18 32 18 4 82 Pb 207.19	2 8 18 32 18 5 83 Bi 208.980	2 8 18 32 18 6 84 Po (210)	2 8 18 32 18 7 85 At (210)	2 8 18 32 18 8 86 Rn (222)

d	f													
2 8 18 18 9 2 57 La 138.91	2 8 18 19 9 2 58 Ce 140.12	2 8 18 21 8 2 59 Pr 140.907	2 8 18 22 8 2 60 Nd 144.24	2 8 18 23 8 2 61 Pm (147)	2 8 18 24 8 2 62 Sm 150.35	2 8 18 25 8 2 63 Eu 151.96	2 8 18 25 9 2 64 Gd 157.25	2 8 18 26 9 2 65 Tb 158.924	2 8 18 28 8 2 66 Dy 162.50	2 8 18 29 8 2 67 Ho 164.930	2 8 18 30 8 2 68 Er 167.26	2 8 18 31 8 2 69 Tm 168.934	2 8 18 32 8 2 70 Yb 173.04	2 8 18 32 9 2 71 Lu 174.97
2 8 18 32 18 9 2 89 Ac (227)	2 8 18 32 18 10 2 90 Th 232.038	2 8 18 32 20 9 2 91 Pa (231)	2 8 18 32 21 9 2 92 U 238.03	2 8 18 32 22 9 2 93 Np (237)	2 8 18 32 23 9 2 94 Pu (244)	2 8 18 32 24 9 2 95 Am (243)	2 8 18 32 25 9 2 96 Cm (247)	2 8 18 32 26 9 2 97 Bk (247)	2 8 18 32 27 9 2 98 Cf (251)	2 8 18 32 28 9 2 99 Es (254)	2 8 18 32 29 9 2 100 Fm (253)	2 8 18 32 30 9 2 101 Md (256)	102 No (254)	103 Lw (257)

unobtainable in presence of water. For transuranian elements, all valences reported are listed.



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